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SOILS REPORT NO. 5 OCTOBER, 1953

REPRINTED JANUARY, 1989

REPORT OF
RECONNAISSANCE SOIL SURVEY
OF
WINNIPEG AND MORRIS MAP SHEET AREAS

By

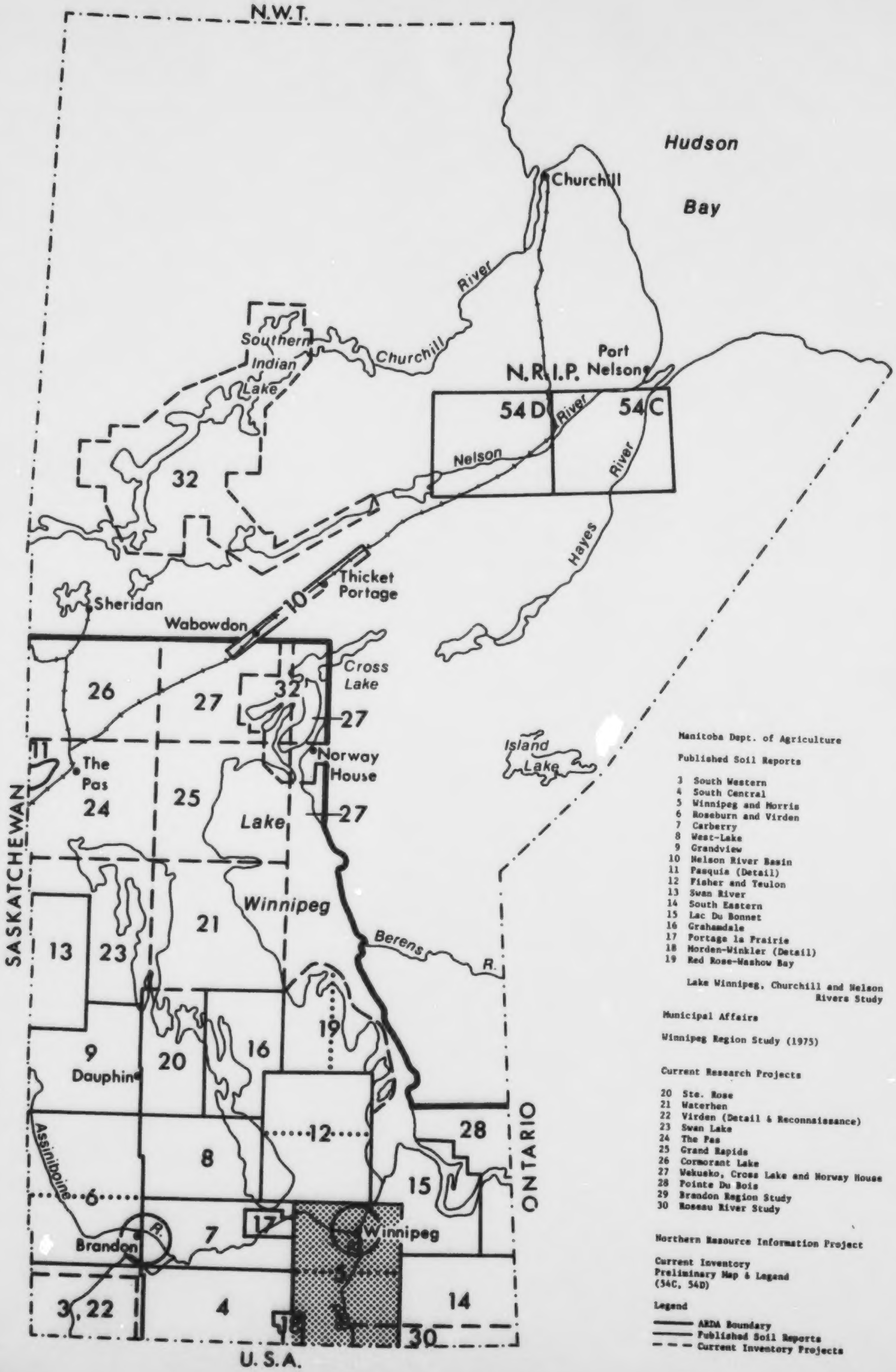
W. A. EHRLICH, E. A. POYSER,
L. E. PRATT and J. H. ELLIS

With two soil maps, one covering Townships 8 to 14 in Range 3 west to Range 8 east (inclusive), designated as the "Winnipeg Area Map Sheet", and one covering Townships 1 to 7 in Range 3 west to Range 8 east (inclusive), designated as the "Morris Area Map Sheet", prepared by the Manitoba Soil Survey.

MANITOBA SOIL SURVEY

CANADA DEPARTMENT OF AGRICULTURE, PROVINCIAL DEPARTMENT OF AGRICULTURE
AND SOILS DEPARTMENT, THE UNIVERSITY OF MANITOBA

Report published by the Manitoba Department of Agriculture.
Maps published by Canada Department of Agriculture.


N.W.T.
Hudson
Bay
Churchill
River
Churchill
Southern
Indian
Lake
Port
Nelson
N.R.I.P.
54 D
54 C
River
Nelson
River
Hayes
32
Thicket
Portage
10
Sheridan
Wabowdon
Cross
Lake
26
27
32
27
11
The
Pas
24
25
Norway
House
Lake
27
Island
Lake
SASKATCHEWAN
13
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21
Winnipeg
Berens
R.
19
9
Dauphin
20
16
12
28
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ONTARIO
Assiniboine
6
R.
17
7
Brandon
Winnipeg
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3, 22
4
18
14
30
U.S.A.

Manitoba Dept. of Agriculture

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5	Winnipeg and Morris
6	Roseburn and Virden
7	Carberry
8	West-Lake
9	Grandview
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Current Inventory
Preliminary Map & Legend
(54C, 54D)

Legend

━━━	ARDA Boundary
───	Published Soil Reports
– – –	Current Inventory Projects

SOIL MAP AREAS OF MANITOBA

SOILS REPORT NO. 5 OCTOBER, 1953

REPORT OF

RECONNAISSANCE SOIL SURVEY

OF

WINNIPEG AND MORRIS MAP SHEET AREAS

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W. A. EHRLICH, E. A. POYSER,
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With two soil maps, one covering Townships 8 to 14 in Range 3 west to Range 8 east (inclusive), designated as the "Winnipeg Area Map Sheet", and one covering Townships 1 to 7 in Range 3 west to Range 8 east (inclusive), designated as the "Morris Area Map Sheet", prepared by the Manitoba Soil Survey.

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AND SOILS DEPARTMENT, THE UNIVERSITY OF MANITOBA

Report published by the Manitoba Department of Agriculture.
Maps published by Canada Department of Agriculture.

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The soil survey of the Winnipeg and Morris Map Sheet Areas was conducted as a joint project by the Canada Department of Agriculture, the Manitoba Department of Agriculture; and the Soils Department, The University of Manitoba.

The undersigned gratefully acknowledges the financial assistance provided by the Canada and Manitoba Departments of Agriculture for the pursuance of this project, and desires especially to acknowledge the interest in and support given to the work, both by the Director of the Experimental Farms Service and by Dr. P.O. Ripley, Chief, Field Husbandry Division, Ottawa; and also by the Provincial Minister of Agriculture and his Deputy, Mr. J.R. Bell.

The mapping of the soils in the southern section of the Red River Plain was initiated by J.H. Ellis and W.H. Shafer, assisted by H. Whitby, J. Forsythe and J. Poole; it was extended and completed by W.A. Ehrlich, W.H. Shafer, E.A. Poyser, L.E. Pratt, R.A. Wallace and J.A. Barr, assisted at various times by I.D. Steeves, M.K. Mitchell and A. Quadrelli. The soil survey in total was carried out under the direction of the undersigned, who hereby makes grateful acknowledgment of the service rendered by these men in the field and in the laboratory, and of the general assistance given to the survey workers by Rose M. McLaren who was responsible for recording the field and laboratory data, and for invaluable assistance in the preparation of this report. The various sections of the report were initially prepared by W.A. Ehrlich, E.A. Poyser, and L.E. Pratt; and the report as a whole finally assembled and edited by the undersigned. Two colored soil maps accompany this report; the Winnipeg Area Soil Map was drafted by W.H. Shafer, and the Morris Area Soil Map was drafted by J.A. Barr. The final drafting and printing of these soil maps was undertaken and financed by the Experimental Farms Service, Canada Department of Agriculture, Ottawa; and the printing of the report was undertaken and financed by the Provincial Department of Agriculture.

For information provided in respect of shipping facilities, acknowledgment and thanks are due to officials in the offices of the Board of Grain Commissioners, the Canadian National Railway and the Canadian Pacific Railway.

Acknowledgment of agricultural data and of other information obtained from Provincial and Federal publications is recorded by appropriate footnotes on the pages of the report.

J.H. Ellis,
Professor of Soils &
Director Manitoba Soil Survey.

FOREWORD

The reconnaissance survey of the soils herein recorded was undertaken with the object of obtaining the essential facts about the soils of the area as a whole, of ascertaining the characteristics, the possibilities and the problems of the respective soils, and of defining their respective locations and distribution. This type of survey was adopted because it provides adequate information for a study of the soils from a regional standpoint, and at the same time permits the acquisition of sufficient detail for practical purposes (in view of the prevailing size of the local farm units) at a cost much below that required for a detailed survey.

The larger portion of the area covered by this report is occupied by the extensive clay plain of the Central Lowlands, locally referred to as the Red River Plain. To cover this area, two map sheets were required, i.e.; a northern section -- designated as the Winnipeg Area Map Sheet, and a southern section -- designated as the Morris Area Map Sheet. To accompany these two soils maps, one report has been prepared. The various sections of the report were written to supply the various types of information and different degrees of detail required by different users of the report.

For the reader who requires a more or less general outline of the area and its soils, a study of the soil maps, supplemented by the summary information given in Tables No. 6, 7, 19, 20, 21, and Appendix I, together with a perusal of Section 2, "General Description"; Section 6 "Agriculture and Land Use"; and an examination of the illustrations of the soil profiles, may suffice. Other readers may require the more comprehensive and detailed information given in other sections of the report. The sequence of the subject matter and the location of specific information contained within the pages of the report, can be ascertained quickly by reference to the Table of Contents.

To insure a common concept of soils and of the terms used, and to define the system of mapping and soil classification followed, a section under the heading of "General Explanatory Notes" is submitted as Appendix I. However, in using the accompanying soil maps, the reader should bear in mind that soils in the field are are rarely uniform, hence a certain degree of variation in the units mapped is inevitable. The soil units shown on the reconnaissance soil maps should be considered as a schematic presentation of the distribution of certain dominant or prevailing soil types, each of which may show some degree of variation, and each of which may contain, as associates, occluded areas of the associated soils that are described in the text but which may be so small in area that it is not practical to separate them out except on larger scale maps.

The writers submit this report in the hope that it will contribute to a better understanding of the soils and land-use problems in this area, that it will focus attention on the necessity for soil and water conservation, that it will stimulate individual and collective action in combatting regional and local soil problems, and that it may be a useful guide in planning future land-use policies.

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MUNICIPALITIES OF THE WINNIPEG AND MORRIS MAP SHEET AREAS

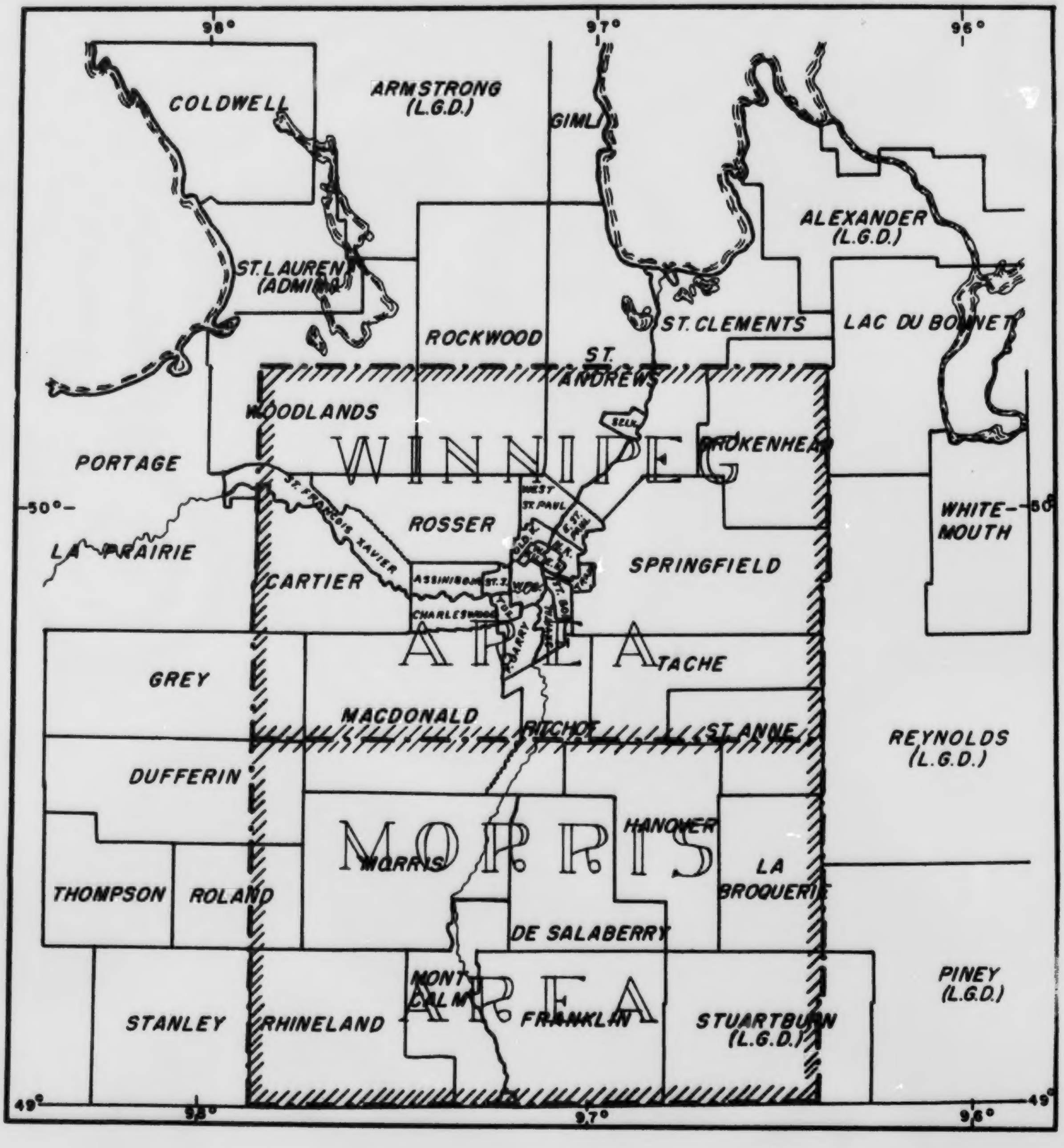
98°
97°
96°
COLDWELL
ARMSTRONG (L.G.D.)
GIMLI
ALEXANDER (L.G.D.)
ST. LAURENT (ADMIN.)
ROCKWOOD
ST. CLEMENTS
LAC DU BONNET
ST. ANDREWS
WOODLANDS
SELK.
BROKENHEAD
WINNIPEG
PORTAGE
WEST ST. PAUL
-50°-
WHITE-MOUTH
50°
ST. FRANCOIS XAVIER
ROSSER
LA PRAIRIE
SPRINGFIELD
CARTIER
ASSINIBOIA
ST. J.
WPG.
CHARLESWOOD
AREA
TACHE
GREY
MACDONALD
RITCHOT
ST. ANNE
REYNOLDS (L.G.D.)
DUFFERIN
HANOVER
MORRIS
LA BROQUERIE
THOMPSON
ROLAND
DE SALABERRY
MONT CALM
PINEY (L.G.D.)
AREA
STANLEY
RHINELAND
FRANKLIN
STUARTBURN (L.G.D.)
49°
98°
97°
96°
49°

Figure No. 1

REPORT OF THE RECONNAISSANCE SURVEY

of the

SOILS OF THE WINNIPEG-MORRIS MAP SHEETS IN MANITOBA.

1. LOCATION AND AREA:

This report of the reconnaissance soil survey of the area covered by the Winnipeg and Morris map sheets involves approximately 3,548,160 acres exclusive of road allowances. It includes Townships 1 to 14 in Ranges 1 to 3 west and in Ranges 1 to 8 east of the Principal meridian. The two map sheets cover the Municipalities of Rhineland, Morris, Montcalm, Franklin, De Salaberry, La Broquerie, Hanover, Ste. Anne, Tache, Richot, Macdonald, Springfield, Charleswood, Assiniboia, Rosser, Fort Garry, St. Vital, East Kildonan, North Kildonan, Old Kildonan, West St. Paul, East St. Paul, Transcona, St. Boniface, St. James, Tuxedo; the cities of Winnipeg and St. Boniface; and portions of the Municipalities of Roland, Dufferin, Grey, Cartier, St. Francois Xavier, Woodlands, Rockwood, St. Andrews, St. Clements, Brokenhead and the Local Government District of Stuartburn. (Figure No. 1.)

2. GENERAL DESCRIPTION: (PHYSICAL FEATURES, ETC.)

The 154 townships in the Winnipeg-Morris map sheets may be grouped into three distinct landscape areas, one of which can be subdivided into a number of sub-areas. These landscape areas are natural units, each of which is distinguished by a combination of physical characteristics. The different aspects presented by the respective landscape areas are due to variations in surface geology, altitude, topography or relief, drainage and native vegetation; they are also affected to a greater or lesser extent by culture or work of man. The landscape areas that occur in these map sheets, (all of which lie within the Lake Agassiz basin), are here designated as follows:-

Landscape Areas Located Below The 850 Foot Contour (Approximate).
- (1) Central Lowland Area.
  - (a) Red River Plain (clay basin, flood plains and river levees).
  - (b) Selkirk-Beausejour (glacio-lacustrine, glacio-fluvial and reworked till) Sub-Area.
  - (c) Woodlands-Stonewall (lake-terrace) Sub-Area.
  - (d) Altona-Emerson ("lacustro-littoral"* and deltaic) Sub-Area.

Landscape Areas Located Above The 850 Foot Contour (Approximate).
- (2) Interlake Reworked Till Plain.
- (3) South-Eastern (lake-terrace, modified till, and glacio-fluvial) Complex.

A general outline of the geology and physical features of the region as a whole is first presented to provide a common background.

* "Lacustro-littoral", is a term here used to designate the more or less sandy materials, transported or reworked by waves and undertow, deposited in the shallow waters of glacial Lake Agassiz or within its receding and advancing margin.

A. PHYSICAL FEATURES AND SURFACE GEOLOGY:

(1) GEOLOGY OF THE UNDERLYING ROCKS:-

The information of the geological formations under the drift in this part of Manitoba is based primarily on well cuttings.* According to the data available, the rocks underlying the Winnipeg-Morris map areas range in age from the Precambrian to the Cretaceous periods, (Figure No. 2). They may be considered as ancestral rocks, the weathered relics of which provide the transported coverings that now form the regolith and the varied parent materials on which the soils have developed.

The Precambrian rocks (either Archean or Proterozoic) are chiefly acidic intrusive rocks. Some outcrops are present in the northeast corner of the sheet in Township 13 and 14 in Range 8 east. These and their contemporaries dip westward and form the base on which all the other rock formations rest.

Rocks of the Palaeozoic era are represented only by those of the Ordovician, Silurian and the Devonian periods. These sedimentaries are principally limestones and dolostones with minor quantities of shales, sandstones and precipitates or evaporites. These rest on the Precambrian formations and extend westward under rocks of the Mesozoic era.

The rocks of the Mesozoic era** include formations of the Jurassic and Cretaceous periods. The Mesozoic sedimentary rocks present are predominantly shales which are interbedded with layers of sandstones, limestones, (some dolomitized limestones) and evaporites. (See legend in Figure No. 2). In the area covered by the Winnipeg-Morris map sheets, all these rock formations are covered by regolith or mantle rock, except where the granitic rocks outcrop in Townships 13 and 14, Range 8 east.

(2) SURFACE GEOLOGY AND PHYSICAL FEATURES:-

The local surface geology here is of especial interest because dynamic geological processes have been responsible for marked textural variations in the parent material of the respective soils. As the result of glaciation during the Pleistocene period, the entire area shown on the Winnipeg-Morris sheets was covered by glacial drift or boulder-till. The boulder-till deposits range in thickness from less than twenty to over two hundred feet.***

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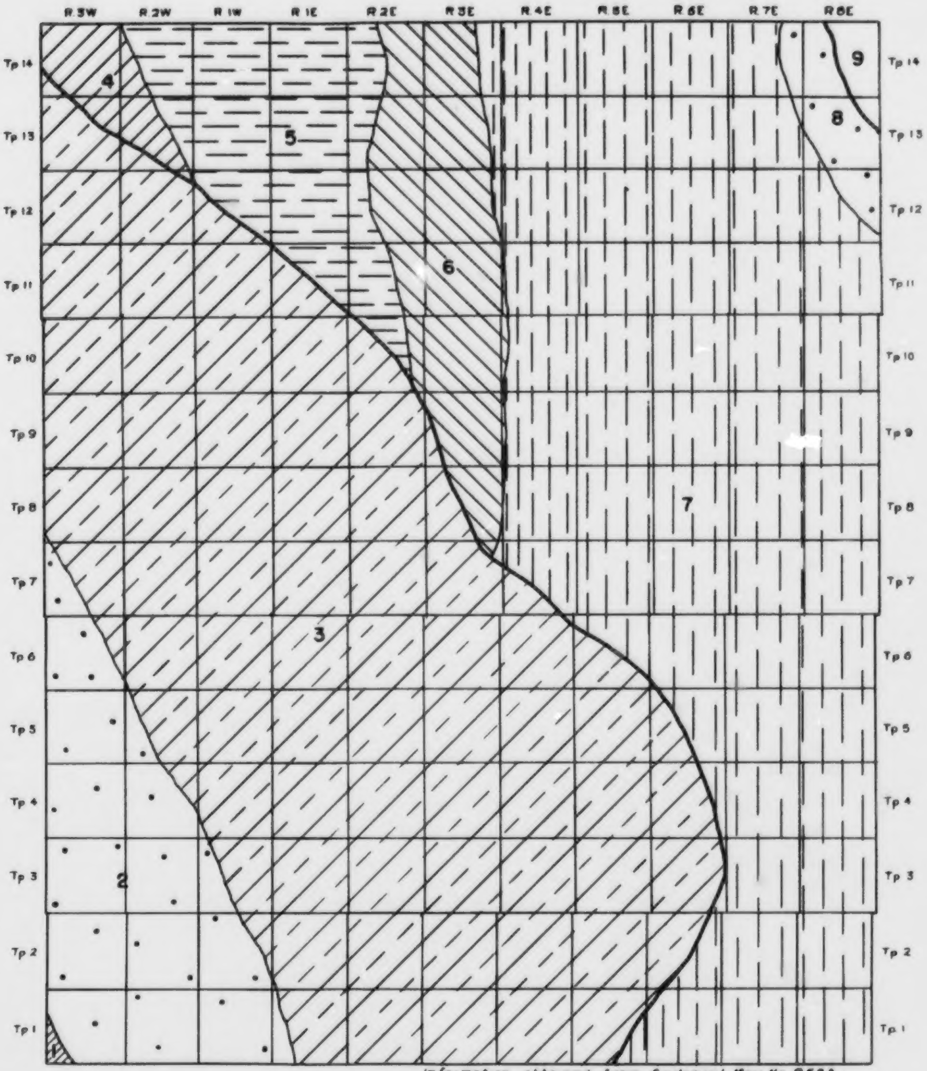
* Kerr, Lillian B., "The Stratigraphy of Manitoba with Reference to Oil and Gas Possibilities", Dept. of Mines and Resources, Mines Branch, Province of Manitoba. Pub. 49-1, 1949.

** Further studies are required to ascertain if rocks of the Triassic period are, or are not present. The Triassic period is represented in North Dakota and Montana by the Spearfish formation but as yet its existence in Manitoba has not been definitely established. The formation originally known as the Amaranth in the Winnipeg-Morris map sheet areas is now referred to as Sundance, Gypsum springs and Spearfish formations. Some lithologic similarity between the Spearfish in Montana and the Original Amaranth has been noted, and although no diagnostic fossils have been found in the Amaranth, it is possible that this formation may prove later to be Triassic in age.

*** "Glacial Lake Agassiz in Manitoba", by Warren Upham, Geo. and Nat. History Survey of Canada, 1890, P 28E.

ROCK FORMATIONS OF THE WINNIPEG-MORRIS MAP SHEET AREAS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R 1W
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R 2E
R 3E
R 4E
R 5E
R 6E
R 7E
R 8E
Tp 14
Tp 13
Tp 12
Tp 11
Tp 10
Tp 9
Tp 8
Tp 7
Tp 6
Tp 5
Tp 4
Tp 3
Tp 2
Tp 1
1
2
3
4
5
6
7
8
9

Information obtained from Geological Map No 850A,
Canada Department of Mines and Resources

MESOZOIC

LOWER AND UPPER CRETACEOUS

▨ 1 ASHVILLE FORMATION: DARK GREY SHALE, MINOR SILT AND SAND, LIMESTONE, BENTONITE.

LOWER CRETACEOUS AND EARLIER

∴ 2 SWAN RIVER GROUP: SAND, SANDSTONE, GLAUCONITIC SAND; GREY, RED AND VARIEGATED SHALE; CLAY.

JURASSIC AND EARLIER

▨ 3 DOLOMITIC LIMESTONE, RED SHALE, GYPSUM, ANHYDRITE.

PALAEOZOIC

DEVONIAN

▨ 4 LIMESTONE AND DOLOMITE.

SILURIAN

☰ 5 STONEWALL FORMATION: DOLOMITE

ORDOVICIAN

▧ 6 STONY MOUNTAIN FORMATION: LIMESTONE AND DOLOMITE, RED SHALE

▥ 7 RED RIVER FORMATION: LIMESTONE AND DOLOMITE.

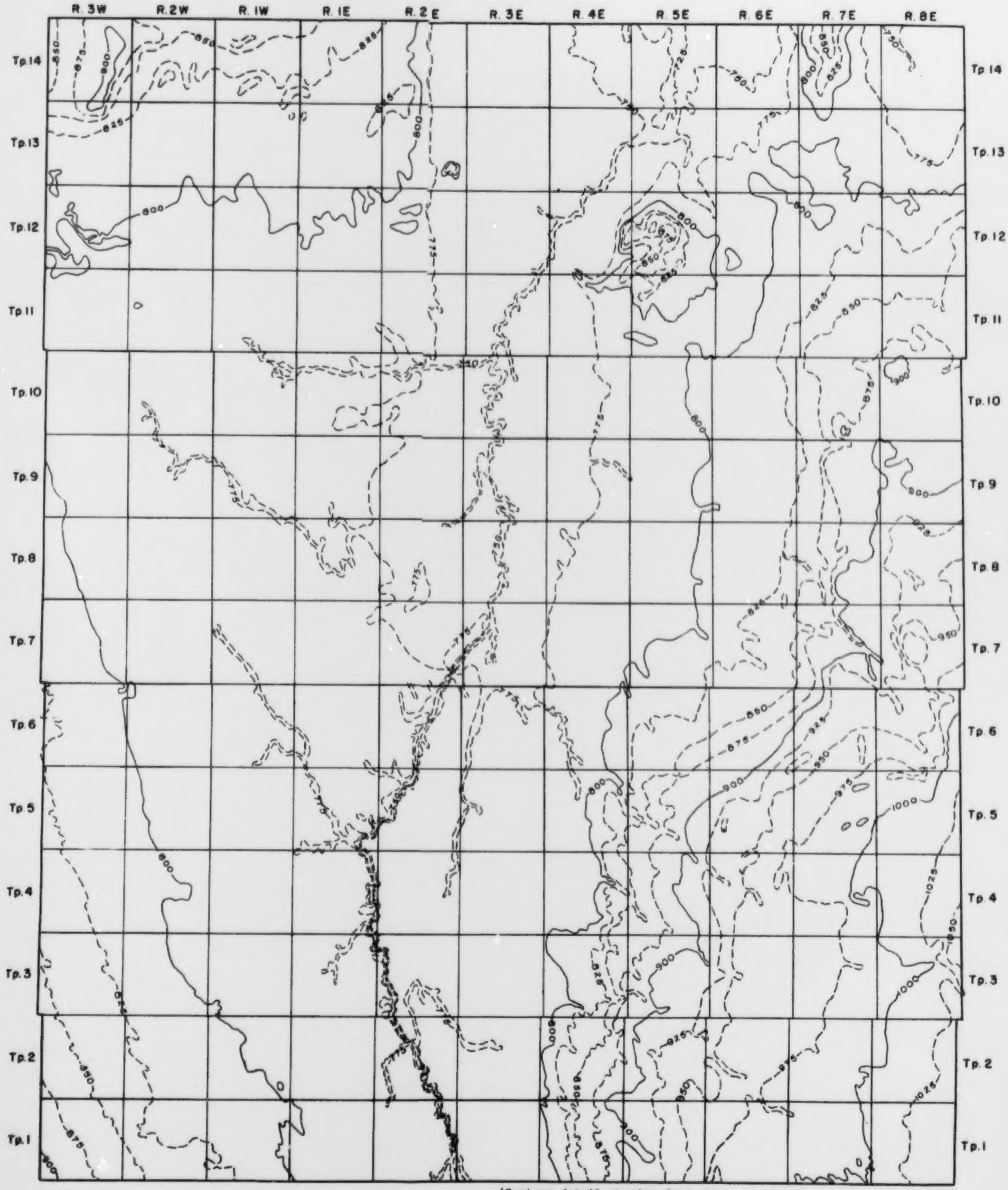
∴ 8 WINNIPEG FORMATION: SANDSTONE, MINOR SHALE

ARCHEAN OR PROTEROZOIC

☐ 9 CHIEFLY ACIDIC INTRUSIVE ROCKS.

Figure No. 2

CONTOUR MAP OF WINNIPEG-MORRIS MAP SHEET AREAS


R. 3W
R. 2W
R. 1W
R. 1E
R. 2 E
R. 3E
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R. 5E
R. 6E
R. 7E
R. 8E
Tp. 14
Tp. 13
Tp. 12
Tp. 11
Tp. 10
Tp. 9
Tp. 8
Tp. 7
Tp. 6
Tp. 5
Tp. 4
Tp. 3
Tp. 2
Tp. 1
800
825
850
875
900
750
775
925
950
975
1000
1025
1050

(Contour detail showing feet above see level, from Sectional Maps)
(No. 73 and 62H. Topographical Survey of Canada.)

Figure No. 3

In this area, the boulder till is composed largely of materials derived from limestones and igneous rocks. The igneous rocks are more plentiful as the Precambrian region is approached, with the result that the soils contain more silicic components in the northeastern portion and more calcareous components in the central and western portions.

From the time of the melting back of the ice in the Pleistocene period to the beginning of soil formation of the existing soils, the glacial drift or till was modified by geological agencies other than ice, and the work of these agencies produced several distinct textural types of soil parent material. In the Lake Agassiz basin, the original till (which consisted of boulders, cobbles, gravel, sand, silt and clay mingled indiscriminantly in an unstratified mass) was modified profoundly by the waters of that glacial lake, and in addition, detritus from the higher lying cretaceous region was carried into the lowlands as the result of erosion and stream transportation.

The Winnipeg-Morris soil map areas lie entirely within the borders of glacial Lake Agassiz which covered the Manitoba Lowlands. In its earlier stages glacial ice formed the northern and eastern boundaries of this lake, and as the ice receded Lake Agassiz gradually receded. At the time when glacial Lake Agassiz was at its greatest height, its shoreline in the latitude of Winnipeg was at an altitude between 1,300 and 1,350 feet A.S.L. The altitude at the C.P.R. Station Winnipeg is in the neighborhood of 757 feet A.S.L. Hence, at its greatest height, the water in the vicinity of Winnipeg must have been between 550 feet and 600 feet in depth.

Along the shorelines and shallows, the waves of this gigantic lake had sufficient force to erode the ice-laid drift. In some sites distinctive escarpments and terraces were cut by wave action and undertow. In such sites, a great number of boulders and other coarse fragments remained as a residuum on the land surface. Many areas at the outer extremities of the original lake (as well as elevated areas which became islands that broke the surface as the waters receded) also were covered with a layer of gravel, cobbles, and stones. Such layers range in thickness from several inches to two or more feet. Originally, the gravelly and stony material was distributed proportionately through the drift, but the erosive force of the waves removed the finer particles, and layers of coarse fragments thus accumulated. At subsequent stages, these layers of stony material (which usually rest on modified till), in many cases, were covered with finer textured material. This finer material, which appears to have been brought in and spread over the various sections partly as outwash, varies in thickness from several inches to ten or more feet.

Local types of surface deposits, such as the accumulation of stratified sand and gravel in the form of linear beach ridges, indicate the successive levels at which the lake halted temporarily during its retreat. These beaches range in width from about 10 to 800 yards and have smooth rounded tops and slopes. The representative beaches consist of assorted and stratified gravel and sand; the thickness of this material varies from about 5 to 25 or more feet above the underlying boulder till. In numerous places, ridges were not formed on the shorelines but low ridges were formed in shallow water at some distance from the shore where the friction of the bottom retarded the erosive force of waves and favored the formation of sand bars and spits. In this case the bars so formed would isolate small bodies of water from the principal lake. Generally these bars consist of ridges that show a thin covering of sand or gravel both on their top and on the sides which face away from the lake, and a thick mantle of coarse sediments on the sides which face the main body of water.

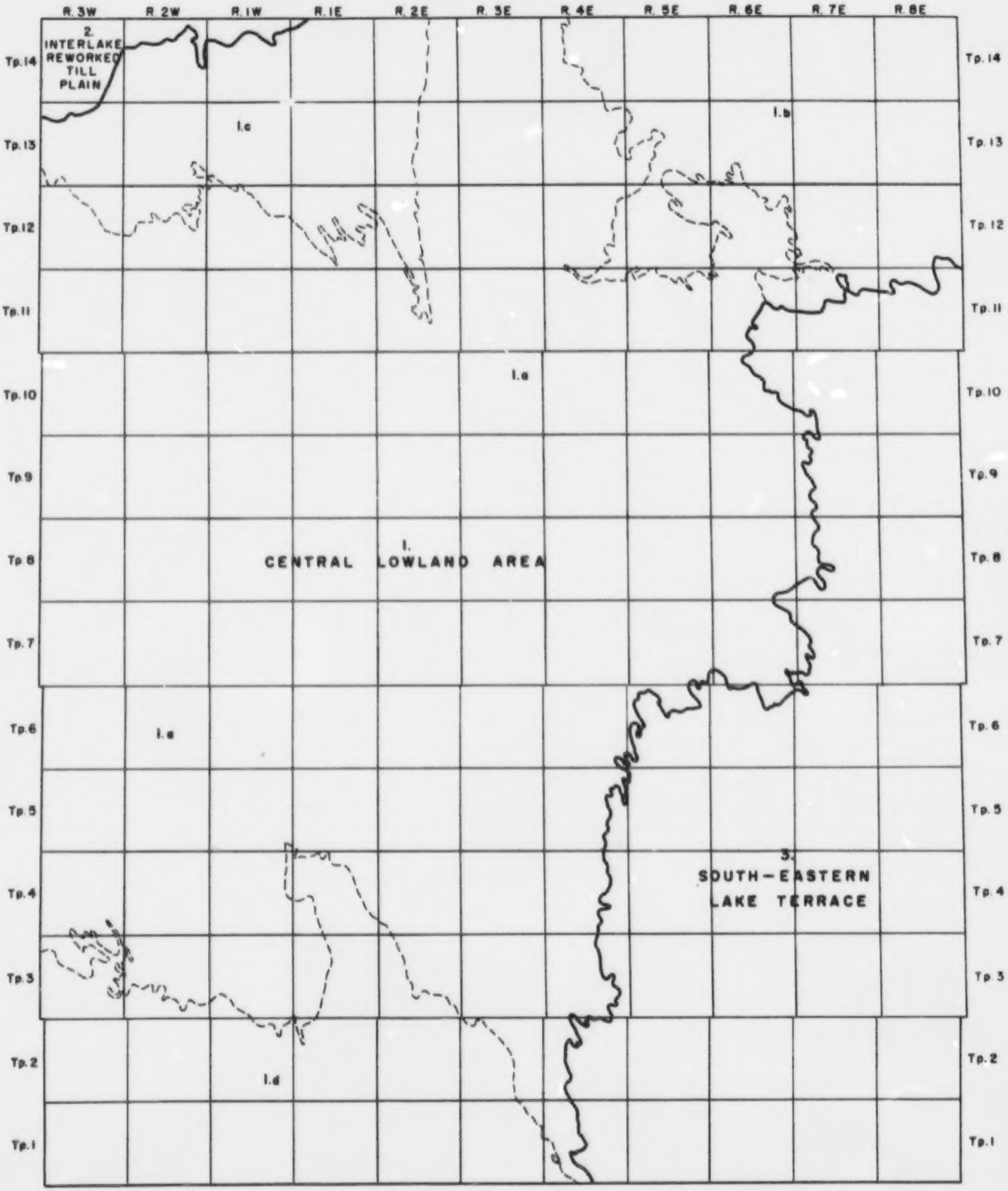
The finer materials removed by water from the superficial section of the drift were transported and deposited in the deeper recesses of the lake bottom. The accumulation of these sediments resulted in conspicuous stratification of the lacustrine deposits in many sections of the basin, and varves of colloidal clay here occur interbedded with thin layers of coarse clay and silt or very fine sand. As the lake receded and its depth decreased, the waves became weaker, and consequently, the materials stirred and transported were the finer fractions consisting dominantly of fine sand, silt and clay. During the period of time when the lake had receded to the Central Lowlands, very fine materials were brought in by streams and tributary lagoons and deposited in the quiet waters of the lake basin.

As the lake reached its last stages, the lower part of the basin became the recipient of alluvial sediments. Some parts of the lake basin through which the Red River now flows probably remained as broad shallow ponds of water which the river and its tributaries filled with fine alluvium. Such sediments, brought into Lake Agassiz by its delta-forming affluents, the Pembina, the Assiniboine, the Boyne, the Roseau, the Rat, the Plum, the Morris, the La Salle and the Seine rivers (which are now tributaries of the Red River), are found spread over large areas of the lake bed. The Brokenhead River and its confluent tributaries located in the northeastern section of the basin also contributed to deltaic sedimentation. The most notable of the deltaic formations deposited in the Winnipeg-Morris map sheet areas are the very fine sand and silty types of soil parent material common to the Emerson, the Altona, the Zora, the Sperling, the Fort Garry and the Lakeland soil associations.

The thickness of the water-laid sediments differs widely. The superficial deltaic and lacustrine materials in the Central Lowlands range up to 60 or more feet thick. The fine sand and silty mantles outside of the central basin range in thickness from several inches to more than ten feet, and rest either on unassorted till or upon earlier lake deposits which are usually finer in texture than the surface deposits.

A number of unique surface deposits and terrain features occur in the eastern portion of the Winnipeg and Morris map sheet areas as the result of advance and retreat of glacial ice within the Lake Agassiz basin. At the time when beaches were being formed along the western and southern shorelines of Lake Agassiz, glacial ice formed its eastern and northern boundaries. The margin of this continental ice sheet was not in continuous retreat but oscillated backward and forward. Sometimes it advanced, in the waters of the lake, faster than it was melting, and during its advance the till carried by the ice and the deposits on the lake floor were pushed up to form subaquatic moraines and lake-terraces in and under the water. In some cases the varve clays at the bottom of the lake were foliated and distorted. Furthermore when the ice advanced, the lake water was deepened so that shore deposits and shallow water-laid sediments were submerged under deeper waters. Thus fine textured sediments were deposited over coarse textured deposits. These various drift deposits were affected profoundly, not only by the lake waters at the time of deposition, but also by wave action as the ice retreated and the lake levels were lowered. Hence in the eastern part of the Morris map sheet area, the terrain is now a lake-terrace complex on which the superficial deposits consist of till, subaquatic till, resorted till, till with a mantle of water-laid sediments, sand with enormous boulders, lacustrine deposits, etc. Thus the varied nature of the surface deposits in the Agassiz basin, and the further modification of the surface formations which occurred after the recession of the waters due to erosion and deposition by wind and water, are here responsible for wide variations in soil texture and in soil parent material.

LANDSCAPE AREAS AND SUB-AREAS


R. 3W
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R. 5E
R. 6E
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R. 8E
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Tp. 5
Tp. 4
Tp. 3
Tp. 2
Tp. 1
2. INTERLAKE REWORKED TILL PLAIN
1.c
1.b
1.a
1. CENTRAL LOWLAND AREA
1.a
3. SOUTH-EASTERN LAKE TERRACE
1.d

Figure No. 4

Figure No. 5
Red River Plain sub-area; showing flat topography, and native tall prairie grass with waxberry, goldenrod, and associated herbaceous vegetation.

Figure No. 6
Selkirk-Beausejour sub-area. View in Pine Ridge district, looking northwest over hills of glacio-fluvial deposits, and showing invasion of grassland by mixed woods.

The altitude of the Winnipeg-Morris map sheet areas ranges from 725 feet to 1050 feet A.S.L., as shown by the contour sketch map (Figure No. 3) The Burnside and the Ossowa beaches of Lake Agassiz which are in the neighborhood of 850 and 825 feet respectively above sea level* divide the map sheet areas into two distinctly different types of terrain. Below the 825 foot level the terrain is flat and covered with clay and fine sediments, above the 850 foot level the terrain is largely reworked till plain, lake-terrace and glacio-fluvial complex.

The configuration of the surface due to geological agencies and the nature of the surface deposits, together with the varied local and regional vegetation, combine to give different aspects to what are here termed "natural landscape areas". The landscape areas and sub-areas into which the region as a whole has been divided are outlined geographically in the sketch map presented as Figure No. 4. They are described separately in the following sections of this report.

B. LANDSCAPE AREAS:

AREAS LOCATED BELOW THE 850 FOOT CONTOUR (APPROXIMATE):-

(1) CENTRAL LOWLAND AREA:

The landscape area designated as the Central Lowland area is a flat expanse in the central and lower-lying part of the Lake Agassiz basin. In general this area lies below the 850 foot contour except in the southwestern portion where the elevation rises to a somewhat higher level. However, this southwestern portion is included as part of the Central Lowland landscape area because of the superficial similarity in character.

This flat lowland area may be divided into four sub-areas or components. i.e.; (a) The Red River Plain Sub-Area; (b) The Selkirk-Beausejour (glacio-lacustrine, glacio-fluvial and reworked till) Sub-Area; (c) The Woodlands-Stonewall (lake-terrace) Sub-Area; and (d) The Altona-Emerson ("lacustro-littoral" and deltaic) Sub-Area. (See Figures No. 5, 6, 7 and 8).

(a) The Red River Plain Sub-Area:

The Red River Plain sub-area is a clay basin, with local flood plains and river levees, that occupies the flat depressional section which was covered, for a long period of time, by the deep waters of glacial Lake Agassiz. The major portion consists of lacustrine clay and alluvial deposits which range from a few feet to 60 or more feet in thickness. Most of this central clay plain may be designated as flat, but micro-relief is evident in the form of low clay ridges that impart a very slightly undulating appearance to much of this sub-area. These low ridges run generally in a north-northwesterly to south-southeasterly direction.

In some sites, deltaic and outwash sediments have been deposited over the lacustrine clays, and in some places the deltaic deposits were covered subsequently with fine textured alluvium. These layered sediments occur at widely scattered points in the landscape, but more especially along the western and northern portions and adjacent to the streams. Natural levees also have been built up along the banks of certain streams.

* Due to uplift of the terrain that occurred when the load of ice and water was removed, the beaches at the present time do not follow the contour lines exactly.

The outstanding feature of the Red River Plain is the characteristic broad flat expanse of terrain which slopes almost imperceptibly from the margin to the Red River and from south to north. The only natural breaks in the monotony of this central plain are the channels cut through the lacustrine clays by the Red River and its tributary streams, (i.e.; the Assiniboine, the La Salle, the Morris, the Roseau, the Rat, and the Seine rivers). Since settlement, an extensive system of drainage ditches has been responsible for reclamation of wet meadow areas. At the present time these ditches and their respective spoil banks are a noticeable feature of the landscape.

The native vegetation of the clay plain originally consisted of tall prairie grass, meadow - prairie grass and meadow grass associations which correspond with the various degrees of natural drainage. Trees grow naturally only as a fringe of woods that mark (and still delineate) the stream channels. The native species of trees that fringe the streams occupy only a small percentage of the total acreage, nevertheless they are of particular interest because, where they occur, they can be used as indicators of land use and of suitable and unsuitable building sites. Oak (Quercus macrocarpa) and aspen (Populus tremuloides) with an undergrowth of snowberry (Symphoricarpos occidentalis), hazel (Corylus spp.) and dogwood (Svida stolonifera) commonly occur on the better-drained sites above, and adjacent to, the river channels; but elm (Ulmus americana), basswood (Tilia americana), cottonwood (Populus deltoides), box-elder (Negundo interius) and ash (Fraxinus pennsylvanica) with an undergrowth of willow (Salix spp.), ferns and allied herbaceous plants are confined to alluvial deposits on the silty clay river terraces and flood plains, and are an indication of periodic innundation and flooding hazards. Some shrubs such as saskatoon (Amelanchier alnifolia), high bush cranberry (Viburnum trilobum) and nannyberry (Viburnum lentago), etc., are common to both associations. Since settlement, agricultural crops have replaced the original vegetative cover over most of this subarea, except on some of the poorly drained meadow soils and on the narrow wooded strips that remain as a fringe along the streams and intermittent water courses.

This landscape area is in the Blackearth soil zone and the well-drained soils on the various parent materials are blackearth-like in character. Nevertheless, Blackearth - Meadow, Alkalinized, Salinized and Meadow soils occur extensively as associates in the intermediately drained and hydromorphic, or locally humid sites.

(b) The Selkirk-Beausejour Sub-Area:

The Selkirk-Beausejour sub-area, the surface deposits of which consist of glacio-lacustrine, glacio-fluvial and reworked till, lies in the northeast corner of the Winnipeg map sheet. It is part of the Lake Agassiz basin but it has undergone invasion by oak and aspen and has a different appearance to the central clay basin. The terrain here varies from a level plain in the Brokenhead district to a gently undulating plain in the western portion. At several points outcrops of boulder till occur and, in addition, two prominent and irregular hills of outwash sand and gravel rise through and above the plain.

One of these, in Township 12, Range 4 and 5 east, known as Birds Hill rises approximately 100 feet above the surrounding plain, (Figure No. 3) and was described by Upham* as an osar. It is one of a series of coarse textured glacio-fluvial deposits that occur in the northern and eastern portion of the Central Lowlands area, some of which are below the level of the lake plain. The other noteworthy height of land is an elongated irregular hill composed largely of sand, in Township 14, Range 7 east. This glacio-fluvial sand ridge rises approximately 75 feet above the surrounding plain. The higher altitudes and coarse textured deposits of these local elevated areas, and the spruce and jack pine trees here associated with the more widely distributed poplar and oak, are responsible for a distinctly different local aspect. These local hills formerly outcropped as islands in Lake Agassiz and now stand out as islands in the lake plain. Small isolated islands of limestone rock covered by a thin mantle of stony till also rise slightly above the general level of the surrounding lacustrine plain in the Garson and adjacent districts. These provide a further distinguishing feature of this sub-area. Small outcrops of granitic rock also outcrop in Townships 13 and 14 Range 8 east.

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* "Glacial Lake Agassiz in Manitoba", by Warren Upham, Geo. and Nat. History Survey of Canada, 1890, P 38E.

Except for the islands of mixed woods on the protruding hills, the vegetation throughout the Selkirk-Beausejour sub-area may be considered as recent Boreal forest invasion of prairie. Young growths of aspen (Populus tremuloides) and oak (Quercus macrocarpa) are dominant, and scrubby specimens of oak are characteristic of the sites where limestone rock comes relatively close to the surface. On Birds Hill and the adjacent Pine Ridge, white spruce (Picea glauca) and jack pine (Pinus banksiana) are associates of oak and aspen. Box-elder (Negundo interis), elm (Ulmus americana) and birch (Betula papyriferia) occur along the streams. Fen peat has developed on some of the flat poorly drained areas and here, in some sites, the meadows have been invaded by tamarack (Larix laricina), black spruce (Picea mariana), black poplar (Populus balsamifera) and willow (Salix spp.)

This sub-area is in the Grey-Black and degrading Blackearth soil zone. The dominant genetic soils are Grey - Blacks but Blackearth, Grey Wooded, Rendzina, degrading Rendzina, Half-Bog and Bog soils occur as associated genetic types.

(c) Woodlands-Stonewall Sub-Area:

The Woodlands-Stonewall sub-area is a lake-terrace of the Central Lowlands and is located in the northwest section of the Winnipeg map sheet area. The land lies more or less between the 800 and 850 foot contour levels, (see Figures No. 3 and 4), and forms the lower of two step-like lake-terraces. This lower terrace is mainly a transition between the lacustrine plain to the south and the lake-scoured terrain of the Interlake Reworked Till Plain. It consists of a relatively thin mantle of lacustrine and outwash sediments lying over calcareous till, except where low moraine-like ridges of geologically eroded till occur at irregular intervals. The most conspicuous of these ridges is a long elevated strip that runs north and south from Stonewall and west of the Balmoral bog. In places the ridge has been lowered materially by geological erosion and in places a succession of small gravel beaches occur. Limestone bedrock is at or near the surface in several locations. Stony Mountain and Little Stony Mountain are noticeable erosion remnants.

The native vegetation in the Woodlands-Stonewall sub-area originally was tall prairie grasses and herbs intermixed with islands of aspen and oak, but due to cultivation the native vegetation is now confined largely to the more stony areas and to the poorly drained sites. This sub-area is in the Blackearth zone but degrading Blackearth, Blackearth - Meadow, Saline and Meadow soils occur as associates of the typical Blackearths.

(d) The Altona-Emerson Sub-Area:

The Altona-Emerson sub-area, the surface of which consists of "lacustro-littoral" and deltaic deposits, lies in the southwestern portion of the Morris map sheet area. From the southwestern corner Township 1, Range 3 west, where the elevation is 900 feet A.S.L., the land falls eastward to the site of the Principal meridian and averages about 6 to 8 feet per mile, but from the site of the Principal meridian to the Red River the fall is around 2 feet per mile. The topography is smooth and very gently sloping to almost level, but low and more or less continuous ridges are to be seen running in a northwesterly and southeasterly direction. The terrain on the western portion consists of sandy "lacustro-littoral" and deltaic sediments. However recent clay overwash from shallow runways occurs as a surface mentle in a number of sites. In the eastern and flatter portion, the dominant sediments have been derived from the Walhalla delta and are silty to silty clay in texture.

The original vegetation here has largely disappeared due to the extensive development of arable culture. Crops and windbreaks have replaced the original cover of prairie grass, but native wooded strips still occur adjacent to the streams and shallow water runways, and a fringe of oak surrounds the "so-called" Lake Louise in Township 1, Range 2 east.

A striking feature of the terrain in the western portion is the rows of trees which mark the village sites. Many of these windbreaks were planted in the early days of settlement by the Mennonites who pioneered this area.*

This sub-area is in the Blackearth zone. In the western portion Blackearth soils are dominant; in the flat eastern portion internal drainage is imperfect, and calcareous Blackearth - Meadow and saline Meadow soils are widely distributed as associates of the better-drained Blackearths.

AREAS LOCATED ABOVE THE 850 FOOT CONTOUR (APPROXIMATE):-

(2) INTERLAKE REWORKED TILL PLAIN:

Only a relatively small acreage of this landscape area occurs in the extreme northwestern portion of the Winnipeg map sheet area. It is part of the extreme southern portion of the Interlake plain, which here forms a second or upper step-like lake-terrace above the Woodlands-Stonewall terrace, (Page 7). Its contact with the Woodlands-Stonewall (lake-terrace) sub-area is marked by a sharp rise in elevation (between the 825 foot to 850 foot levels) and by distinctive gravel beaches. North of these beaches the landscape is a slightly undulating plain traversed by intermittent low ridges of till with a thin covering of coarse textured reworked sediments. The land between the ridges consists of imperfectly drained swales. The terrain in general has been modified by wave action and the surface deposits are more or less stony and strongly calcareous. (See Figure No. 9).

The native vegetation consists of willow and stunted aspen with an occasional scrubby type of oak together with prairie and meadow - prairie grasses and calciphilous herbs. Due to the highly calcareous character of the soils, the vegetation as a whole is less vigorous than in the adjacent landscape areas to the south. The presence of stones, gravel, imperfect drainage, and low vigor of the vegetation resulting from the high lime content of the soils, has been responsible for the very limited agricultural development of this landscape area.

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* "Farm Forestry and Tree Culture Projects for the Non-Forested Region of Manitoba", by Ellis, J.H.; Gill, C.B.; and Brodrick, F.W. Manitoba Government Publication, 1945. Appendix 2.

(3) SOUTH-EASTERN (Lake-Terrace) COMPLEX:

This landscape area lies east of the Red River Plain and is strikingly different in appearance from the Central Lowland area. Although sometimes referred to as the South-Eastern Lowlands, (because it was covered at one stage by the waters of Lake Agassiz, and it still has a considerable acreage of peat and meadow soils), it has a higher altitude than the Central Lowlands. From an altitude of just below the 850 foot contour at its eastern boundary, the land rises to a height of 1050 feet A.S.L. in Townships 3 and 4, Range 8 east (Figures No. 3 and 4). The terrain is a complex of land forms that have resulted from:-

(a) The deposition of till and subaquatic till when the oscillating ice sheet of the last glaciation formed the eastern boundary of Lake Agassiz; (See Figure No. 10).

(b) The glacio-fluvial deposits that were sorted and sized as they were carried and deposited by the melting ice waters;

(c) Inundation under lake waters as the ice retreated;

(d) Scouring and wave action of the higher sites as they emerged from the receding lake waters; and

(e) Ponding and swamping of the depressional sites during later stages.

Consequently both the surface terrain and the texture of the surface deposits are extremely varied and they are both best designated as a complex.

The native vegetation ranges from wooded invasion of prairie in the western part of this landscape area to typical mixed Boreal forest in the eastern portion. The ecological boundaries are neither well defined nor continuous due to local variation in relief and drainage and in local soil climate. Nevertheless, the density and vigor of forest vegetation increases progressively from west to east and from south to north. The most common trees are aspen (Populus tremuloides), oak (Quercus macrocarpa), together with willow scrub (Salix spp.); and with jack pine (Pinus banksiana) and white spruce (Picea glauca) growing on the sandy soil types; and with tamarack (Larix laricina) and black spruce (Picea mariana) commonly present on the eastern swampy sites.

In this landscape area peat formation is common in the depressional sites, and peat increases in depth and frequency with increase of density of forest cover. Both peat deposition and forest growth therefore indicate an increasingly humid climate over the area to the eastward.

The Blackearth zone, which covers the Central Lowlands, here grades into a Grey - Black or degrading Blackearth zone in the western portion of the South-Eastern Landscape Complex. This zone of mixed Grey - Black and Blackearth soils is from one to three townships wide. East of this zone Grey Wooded soils dominate so that a Grey Wooded soil zone is indicated. The zonal boundaries however have irregular outlines, and soils characteristic of each zone occur as islands within the other. Throughout the South-Eastern Landscape Complex, Grey-Black and Grey Wooded soils are dominant but degarding Blackearth, Meadow, Half-Bog and Bog soils occur as associates.

Because of the mosaic of textural soil classes, many of which are coarse textured and stony, and because considerable areas of peat and meadow soils are widespread, agricultural development has been slow except for local sites that are more favourable. This area is more suited to dairying, livestock production, forestry and wild life than it is for extensive arable culture.

3. CLIMATE:

Within the area covered by the Winnipeg-Morris map sheets there have been a number of meteorological stations in operation for varying periods since 1872. However, with the notable exceptions of Winnipeg and Oakbank, these stations have been operated either for only a few years and then abandoned, or their observations have not been regularly recorded and many annual records are erratic and incomplete. At varying locations in the vicinity of Winnipeg, observations of temperature and precipitation have been recorded continuously since 1872, so that by combining data from these adjacent sites a continuous record covering a period of more than 75 years is now available. Complete records of precipitation at Oakbank are available for the period 1885 to 1931. Temperature records at this station were started in 1890 and except for an interval of seven years between 1895 to 1902, were maintained regularly until the discontinuation of the station in 1931.

(1) PRECIPITATION:

The mean monthly precipitation at Winnipeg, together with the highest and lowest monthly precipitation between the years 1872 and 1949, are given in Table No. 1.

The annual precipitation figures for the 78 years available indicate that the yearly precipitation for the Winnipeg District is 20.49 inches. Figures given in Table No. 1 also indicate that the yearly fluctuations in precipitation range from 13.82 to 30.63 inches. During the period covered by the records there were 9 years in which the precipitation was between 13 and 15 inches; 39 years in which the precipitation was between 16 and 20 inches; 24 years in which the precipitation was between 21 and 25 inches; and 6 years in which it was more than 25 inches. Thus, on the basis of past records, it may be expected that in the vicinity of Winnipeg the precipitation will range between 16 and 20 inches in one year out of two; between 20 and 25 inches, one year in three; between 13 and 15 inches, one year in nine; and over 25 inches one year in thirteen.

In view of the fact that the only other long-period precipitation records that are available in the area of the Winnipeg-Morris map sheets are for Oakbank, a point located 14 miles northeast of Winnipeg, where the mean annual precipitation calculated from 45 years' records is 20.82 inches, the Winnipeg records may be taken as the most reliable precipitation data available for this area. However for comparison purposes, the following are the respective mean annual precipitation figures for stations surrounding this map sheet; (on the west side) Portage La Prairie (38 years), 18.60 inches; Graysville (33 years), 18.32 inches; Morden (61 years), 18.35 inches; and to the east, Sprague (26 years), 20.11 inches.

Table No. 1:- Mean Monthly Precipitation at Winnipeg, Manitoba, and the Highest and Lowest Monthly Means, Compiled for the Years 1872 to 1949 Inclusive*

Month	Number of Years Recording	Mean Monthly Precipitation In Inches	Monthly Precipitation Range In Different Years	
			Highest Monthly Precipitation	Lowest Monthly Precipitation
January...	78	.86	3.36 (1916)	.12 (1902)
February..	78	.85	3.93 (1881)	.10 (1903)
March.....	78	1.15	3.00 (1904)	.06 (1939)
April.....	78	1.10	5.64 (1896)	.08 (1949)
May.......	78	2.15	5.88 (1880)	.03 (1917)
June......	78	3.06	10.07 (1901)	.45 (1889)
July......	78	2.98	7.14 (1914)	.61 (1925)
August....	78	2.48	9.42 (1876)	.13 (1915)
September.	78	2.28	8.09 (1872)	.05 (1948)
October...	78	1.46	5.67 (1898 & 1949)	.21 (1906 & 1920)
November..	78	1.08	3.03 (1918)	.06 (1901 & 1939)
December..	78	.94	3.99 (1909)	.10 (1892)
		Yearly Mean	Highest 12 Months November to October	Lowest 12 Months November to October
		20.49	30.63 (1878)	13.82 (1889)

* The precipitation and temperature data were obtained from the published records of the Dominion Meteorological Service.

For reference purposes and to facilitate the comparison of precipitation with crop yields, the precipitation records from the Winnipeg Meteorological Stations are expressed as seasonal means in Table No. 2. This table shows the winter precipitation during November to March when the mean monthly temperatures are below freezing; the spring, summer and fall precipitation during April to October; and the yearly precipitation for the 12 months from November to October. The precipitation during the months when the ground is not frozen has been grouped and expressed as fall precipitation for the months of August to October prior to the season in which the crops are grown, and in addition the precipitation from April to July in each crop year is shown. The total precipitation for the previous August to October, plus that of April to July, is also listed for comparison with the yields of cereal crops

The figures in Table No. 2 bring out the fact that the precipitation which falls during April to July in many years is not sufficient to produce high yields of grain, unless supplemented by a moisture carryover from the previous fall. However, the precipitation values for the fall months of August to October, plus the rainfall during the four grain-growing months of April to July, are usually adequate for the production of satisfactory crops, so that, if droughts occur, they are of short duration and severe or long continued droughts are of very rare occurrence. On the other hand, annual precipitation figures as well as seasonal figures indicate that

Table No. 2:- Seasonal Precipitation at Winnipeg, Manitoba, in Inches, Expressed as the Seasonal Means for the Years 1872 to 1949 inclusive.

Crop Year	Previous Winter Precipitation, November to March	Spring, Summer, and Fall April to October	Year November To October	Crop Season		
				Previous Fall August to October	Growing Season April to July	Previous Fall, August to October Plus April to July
1872	....	26.13	.....	.....	14.64	.....
1873	2.93	14.21	17.14	11.49	10.22	21.71
1874	3.04	16.60	19.64	3.99	10.16	14.15
1875	3.59	15.77	19.36	6.44	8.65	15.09
1876	5.66	22.86	28.52	7.12	11.32	18.44
1877	4.88	20.23	25.11	11.54	15.60	27.14
1878	6.92	23.71	30.63	4.63	17.20	21.83
1879	4.58	21.14	25.72	6.51	17.22	23.73
1880	6.22	22.50	28.72	3.92	12.59	16.51
1881	6.18	12.28	18.46	9.91	6.36	16.27
1882	8.75	16.91	25.66	5.92	10.60	16.52
1883	4.62	15.64	20.26	6.31	7.57	30.40
1884	5.20	20.03	25.23	8.07	7.85	15.92
1885	3.73	12.78	16.51	12.18	9.46	21.64
1886	3.32	12.62	15.94	3.32	5.47	8.79
1887	3.67	12.82	16.49	7.15	14.58	21.73
1888	4.59	13.77	18.36	3.71	8.45	12.16
1889	3.87	9.95	13.82	5.32	5.47	10.79
1890	4.98	21.15	26.13	4.48	11.37	15.85
1891	2.93	15.86	18.79	9.78	8.71	18.49
1892	4.92	14.80	19.72	7.15	9.37	16.52
1893	5.98	17.35	23.33	5.43	13.82	19.25
1894	6.75	11.89	18.64	3.53	7.15	10.68
1895	5.71	12.44	18.15	4.74	9.97	14.71
1896	6.00	21.41	27.41	2.47	16.93	19.40
1897	4.94	12.96	17.90	4.48	10.29	14.77
1898	5.79	20.06	25.85	2.67	9.74	12.41
1899	5.58	16.19	21.77	10.32	10.01	20.33
1900	2.59	15.14	17.73	6.18	6.32	12.50
1901	3.48	21.44	24.92	8.82	12.62	21.44
1902	4.03	14.16	18.19	5.96	9.99	15.95
1903	3.98	12.94	16.92	4.17	7.48	11.65
1904	6.54	17.01	23.55	5.46	12.00	17.46
1905	4.22	16.57	20.79	5.01	12.57	17.58
1906	3.62	17.33	20.95	4.00	14.28	18.28
1907	6.64	12.47	19.11	3.05	7.48	10.53
1908	4.97	16.17	21.14	4.99	9.63	14.62
1909	5.36	14.08	19.44	6.54	8.21	14.75
1910	8.34	12.29	20.63	5.87	6.32	12.19
1911	4.56	20.78	25.34	5.97	14.18	20.15
1912	1.96	21.14	23.10	6.60	12.86	19.46
1913	2.61	13.05	15.66	8.28	6.30	14.58
1914	3.22	17.55	20.77	6.75	11.00	17.75
1915	3.67	12.57	16.24	6.55	6.52	13.07
1916	8.59	16.43	25.02	6.05	9.73	15.78
1917	4.33	10.64	14.97	6.70	5.65	12.35
1918	3.12	12.75	15.87	4.99	7.86	12.85
1919	6.69	19.79	26.48	4.89	11.80	16.69
1920	6.81	11.21	18.02	7.99	5.97	13.96
1921	7.04	15.91	22.95	5.24	8.89	14.13
1922	3.71	15.27	18.98	7.02	10.40	17.42
1923	7.78	10.54	18.32	4.87	8.30	13.17
1924	2.11	15.75	17.86	2.24	8.04	10.28
1925	6.01	11.09	17.10	7.71	4.39	12.10
1926	2.50	16.55	19.05	6.70	6.53	13.23
1927	3.22	18.62	21.84	10.02	10.06	20.08
1928	3.72	16.79	20.51	8.56	12.55	21.11
1929	4.06	10.13	14.19	4.24	6.29	10.53
1930	4.94	17.69	22.63	3.84	12.41	16.25
1931	3.47	14.30	17.77	5.28	6.98	12.26
1932	5.44	12.65	18.09	7.32	7.17	14.49
1933	4.82	15.82	20.64	5.48	8.83	14.31
1934	6.17	15.47	21.64	6.99	7.43	14.42
1935	6.32	16.73	23.05	8.04	8.97	17.01
1936	6.22	9.21	15.43	7.76	5.66	13.42
1937	4.32	15.11	19.43	3.55	9.99	13.54
1938	5.81	10.48	16.29	5.12	8.10	13.22
1939	4.37	13.81	18.18	2.38	6.36	8.74
1940	2.24	13.73	15.97	7.45	8.72	16.17
1941	3.65	21.20	24.85	5.01	9.66	14.67
1942	4.44	16.89	21.33	11.54	12.42	23.96
1943	5.70	15.80	21.50	4.47	10.80	15.27
1944	3.80	18.50	22.30	5.00	10.50	15.50
1945	6.54	16.01	22.55	8.00	7.87	15.87
1946	4.94	12.69	17.63	8.14	5.35	13.49
1947	4.82	15.78	20.60	7.34	8.82	16.16
1948	4.81	10.96	15.77	6.96	9.58	16.54
1949	6.71	16.26	22.97	1.38	6.79	8.17
Seasons	77	78	77	77	78	77
Means	4.86	15.76	20.49	6.17	9.58	15.90

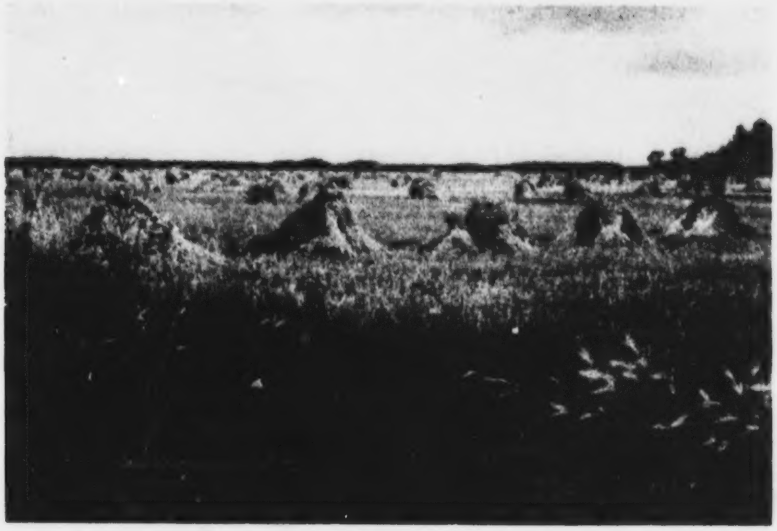

Figure No. 7
Woodlands-Stonewall sub-area; or lower step-like lake-terrace between the Red River Plain and the Interlake Reworked Till Plain.

Figure No. 8
Altona-Emerson sub-area; showing smooth topography of "lacustro-littoral" and deltaic deposits, tall prairie vegetation, and typical Mennonite village on Altona soil.

in some years and in some seasons, the rainfall may be sufficiently high above the respective means so that, in the sections where topography is flat and the soils are of clay texture, excess surface water and drainage may and do become temporary problems.

(2) TEMPERATURE:

The average mean monthly temperatures at Winnipeg, together with the highest and lowest mean monthly temperatures between the years 1874 and 1949, are given in Table No. 3.

Table No. 3: Mean Monthly Temperatures at Winnipeg, Manitoba, and the Highest and Lowest Monthly Mean, Compiled for the Years 1874 to 1949 Inclusive.

Month	Number of Years Recording	Mean Monthly Temperatures In Degrees Fahrenheit	Range of Mean Temperatures	
			Highest Monthly Mean IN Degrees Fahrenheit	Lowest Monthly Mean IN Degrees Fahrenheit
January	76	-2.0	13.0 (1944)	-16.2 (1875)
February	76	1.6	23.8 (1878)	-16.2 (1875)
March	76	16.5	34.7 (1878)	3.2 (1899)
April	75	38.0	48.9 (1915)	27.3 (1893)
May	76	52.1	60.0 (1922)	39.7 (1907)
June	76	62.2	68.9 (1894)	55.4 (1877)
July	76	67.2	75.5 (1936)	61.4 (1884)
August	76	64.4	70.3 (1949)	58.8 (1885)
September	77	54.1	62.1 (1948)	46.1 (1873)
October	77	41.3	51.1 (1914)	32.4 (1887)
November	76	21.9	34.7 (1899)	6.9 (1896)
December	77	6.5	24.5 (1877)	-13.8 (1879)

The figures in Table No. 3 show that the mean temperatures during the months of April to October inclusive are above freezing. The mean monthly temperatures during the months of November to March are below freezing, and hence this is the period during which it may be expected that the ground will be frozen.

For comparison with the precipitation figures, the mean temperatures for the winter months of November to March; for the open months from April to October; and for the 12 months November to October, etc., are given in Table No. 4.

The figures for the seasonal periods by years given in Table No. 4 indicate that the open or growing season temperatures approach very closely to their respective average means and show much less fluctuation than the precipitation figures given in Table No. 2. The temperatures during the winter season, however, fluctuate considerably.

The meteorological data in Tables No. 2 and No. 4 may be summarized by stating that, on the average, the precipitation during the open season is somewhat

Figure No. 9
Interlake Reworked Till plain landscape area; showing the low ridge and swale topography of the more or less stony and calcareous surface deposits.

Figure No. 10
South-Eastern Complex landscape area; showing stony reworked lake-terrace under aspen and associated vegetation.

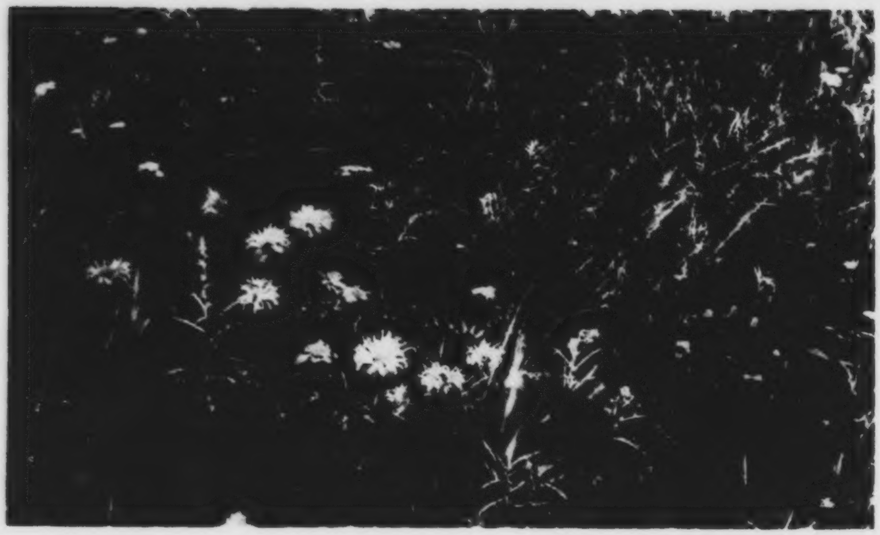

Figure No. 11
Tall prairie grasses and associated herbs characteristic of native vegetation on the well-drained sites of the Central Lowland area.

Figure No. 12
Meadow - prairie and meadow grasses on intermediately and poorly drained sites of the Central Lowland area.

more favorable for crop production than that of South-Central or South-Western Manitoba, and that the temperatures during the growing season are generally favorable for the crops common to the latitude. It should be noted also that although drought periods are of less frequent occurrence in this area than in the southwestern portion of the province, and excessive moisture is a problem during some seasons, nevertheless moisture conservation practices are still a necessary part of the farming program in this area.

(3) NATURAL INDICATORS OF CLIMATE:

The climatic data presented in Tables No. 1, 2, 3, and 4 are from observations made at Winnipeg, which is located within the grassland region of the Central Lowlands. However, the native vegetation throughout the Winnipeg-Morris map sheet area varies from west to east. These variations in native vegetation indicate variations in climate. North and east of Winnipeg, and in the South-Eastern landscape Complex, the open grassland region gives place to forest types of vegetation. In the Interlake Till Plain and in the Woodlands-Stonewall sub-area, the prairie and meadow-prairie vegetation is interspersed with groves of aspen. On Birds Hill, the prevailing vegetation is oak and aspen, with an undergrowth of upland grasses and herbs. In the Selkirk-Beausejour sub-area, oak and aspen, with an occasional white spruce, have invaded and partially supplanted the original grass cover; and in addition, tamarack, black spruce and willow occur in the hydromorphic sites. In the South-Eastern Landscape Complex, the prevailing vegetation is mixed deciduous and coniferous woods, with the conifers becoming more prominent in the eastern portion of the area and peat deposits deeper and more prevalent in the hydromorphic sites.

These variations in vegetation are affected to some extent locally by the influence of soil parent material, topography, and altitude on soil climate; nevertheless, a significant increase in moisture efficiency from west to east is indicated by the increasing prominence of coniferous woods in the eastern portion of the Winnipeg-Morris soil map areas, and by the transition, across these areas, from prairie to forest cover. (See Figures. No. 11, 12, 13, 14 and 15.)

An attempt has been made to correlate the various types of native vegetation with the limited meteorological data available. However, because of the limited number of meteorological stations within the area as a whole, and because of the absence of weather records in certain sections, it was not possible to make direct comparisons of native vegetation and meteorological data in each of the landscape areas and sub-areas. Nevertheless, by using all the available monthly weather records for Morris and Emerson, together with the comparable data for Morden and Portage la Prairie*, it was possible to obtain a composite table of averages to represent the mean monthly precipitation and the mean monthly temperatures in the western and southwestern portions of the area. The Winnipeg meteorological data was taken as representative of the central portion of the area; and the available meteorological data for Oakbank and Sprague were combined in composite tables to represent the mean monthly precipitation and mean monthly temperatures in the eastern portion.

From the available meteorological data thus tabulated, the "precipitation-effectivity" (i.e.; P-E) and the "temperature-efficiency" (i.e.; T-E) values were

* Morden and Portage la Prairie lie to the west and Sprague lies to the east of the Winnipeg-Morris map sheet areas.

Table No. 4: Seasonal Mean Temperatures at Winnipeg, Manitoba, Compiled for the Years 1874 to 1949 inclusive.

Crop Year	Previous Winter November to March	Spring, Summer And Fall April to October	Year November to October	CROP SEASON	
				Previous Fall	Growing Season April to July
1874	3.8	53.3	32.7	....	53.1
1875	-1.0	51.1	29.4	53.6	51.3
1876	1.6	52.0	31.0	50.9	53.1
1877	4.8	52.4	32.6	50.6	53.0
1878	23.4	53.9	41.2	51.6	56.4
1879	7.6	54.6	35.0	50.6	56.0
1880	2.3	52.2	31.4	52.7	53.6
1881	4.8	52.8	32.8	50.4	55.0
1882	7.5	53.3	34.2	50.1	52.2
1883	2.0	50.6	30.3	54.7	51.2
1884	0.8	52.4	30.6	49.7	53.5
1885	1.0	51.5	30.5	51.0	52.9
1886	7.1	55.2	35.2	49.7	57.1
1887	0.4	53.2	31.2	52.7	56.4
1888	1.6	51.4	30.7	49.1	51.7
1889	13.0	53.5	36.6	51.2	55.2
1890	4.1	52.7	32.5	51.3	54.4
1891	10.0	53.7	35.5	50.6	54.3
1892	7.6	52.6	33.9	52.9	52.8
1893	0.1	51.5	30.1	52.5	53.0
1894	3.2	54.5	33.1	49.6	57.2
1895	6.5	53.6	34.0	50.9	55.9
1896	8.0	52.7	34.1	50.5	55.0
1897	5.6	55.3	34.6	49.7	55.0
1898	8.7	53.4	34.8	55.8	54.4
1899	3.0	53.5	32.5	52.1	54.1
1900	11.6	57.6	38.5	52.7	59.1
1901	7.5	56.0	35.8	55.7	57.6
1902	15.2	53.7	37.7	53.8	54.3
1903	10.7	53.8	35.9	53.0	55.3
1904	4.6	52.7	32.7	51.9	53.3
1905	11.7	53.5	36.1	52.0	53.2
1906	12.6	56.3	38.1	54.0	56.6
1907	7.7	50.1	32.4	55.9	49.2
1908	13.2	55.0	37.6	51.2	55.3
1909	10.7	54.4	36.2	54.6	53.4
1910	13.1	56.0	38.1	55.8	57.2
1911	9.1	54.9	35.8	54.4	56.5
1912	8.1	54.6	35.2	52.7	56.2
1913	8.7	54.7	35.5	52.5	56.4
1914	14.0	56.8	38.9	52.5	56.7
1915	13.0	55.3	37.7	56.9	55.4
1916	9.0	53.3	34.9	55.3	54.3
1917	6.8	52.4	33.4	52.0	51.3
1918	11.0	53.3	35.6	50.7	54.0
1919	14.8	56.0	38.8	52.3	59.3
1920	7.0	56.0	35.6	51.7	53.3
1921	14.2	56.6	38.9	59.7	57.5
1922	11.4	57.4	38.3	55.3	58.3
1923	8.8	55.9	36.3	56.3	56.8
1924	16.8	53.3	38.1	54.7	51.3
1925	8.2	54.4	35.2	56.0	56.0
1926	14.2	54.0	37.4	52.3	55.8
1927	11.4	54.6	36.6	51.7	54.0
1928	11.2	53.6	35.9	55.3	54.0
1929	12.4	54.9	37.2	53.0	54.5
1930	9.4	55.8	36.5	55.3	57.0
1931	17.4	55.9	40.7	54.3	56.5
1932	13.8	55.4	38.1	58.3	57.0
1933	7.6	55.6	35.6	53.3	57.3
1934	7.6	54.0	34.7	53.3	55.3
1935	12.2	53.2	36.2	52.3	54.2
1936	2.4	54.6	32.8	52.0	55.9
1937	7.5	55.6	35.6	52.8	56.3
1938	12.2	56.5	38.1	54.6	55.2
1939	7.8	54.5	35.1	58.4	55.5
1940	16.1	56.3	39.6	53.3	54.0
1941	11.8	55.9	37.5	54.9	58.0
1942	16.3	54.1	38.3	53.2	54.1
1943	5.8	54.8	34.4	54.1	54.4
1944	13.5	55.3	37.9	55.2	55.9
1945	15.7	51.6	36.7	54.6	50.6
1946	10.9	54.5	36.3	53.0	56.0
1947	9.6	54.7	35.9	52.6	52.9
1948	7.4	56.5	36.0	57.1	54.7
1949	7.9	56.0	36.0	58.9	56.7
Seasons	76	76	76	75	76
Means	8.9	54.2	35.4	53.2	54.9

Figure No. 13
Moist prairie grassland in the central Lowland area, under invasion by aspen; showing local humid sites (Meadow soils) on which fire has destroyed the shallow peaty surface deposits.

Figure No. 14
Broad-leaved trees that are characteristic of the vegetative cover in the Grey-Black soil zone.

Figure No. 15
Black spruce and associated vegetation characteristic of the wooded bogs that occur on local humid sites within the Grey Wooded zone.

calculated by use of Thornthwaite's formulae*, with the results shown in Table No. 5.

Table No. 5: Meteorological Data Evaluated as (P-E) and (T-E) in Comparison with Native Vegetation as Indicators of Climate.

	Western And South-Western Portion	Central Portion	Eastern Portion
Precipitation-Effectivity	43.3	50.2	53.1
Temperature - Efficiency	40.3	39.1	36.0
Prevailing Vegetation	Tall prairie and meadow-prairie		Aspen grove and forest

The figures in Table No. 5 (although compiled from limited meteorological data) are in line with the indications of climate reflected by the native vegetation. The native vegetation indicates that in the Winnipeg-Morris map areas, a tall prairie and meadow grassland climate prevails in the western and central portion. This obviously grades northward into a somewhat more humid climate under which tree invasion of prairie has taken place; and it grades eastward into a still more humid climate where the vegetation grades through a belt of woodland invasion to the forest zone in the east and southeast.

4. SOILS:

A. SURVEY AND CLASSIFICATION:

The reconnaissance survey of the Winnipeg and Morris map sheet areas was undertaken with the object of obtaining a general picture of the soils that occur in the area, and of ascertaining their character and distribution, rather than of making a detailed soil map which might be expected to show all the soil types and variations that occur on individual farms.

(1) METHOD OF SURVEY:

In conducting this survey a traverse was made along each road allowance, thus giving lines of traverse one mile apart, and permitting the observation of at least two sides of each quarter section. Foot traverses inside the sections (which are an essential procedure in a detailed soil survey) were rarely made unless some important detail was required which could not be obtained from the ordinary lines of traverse. Along the lines of traverse the soils were examined at from one-quarter to one-half mile intervals, or more frequently if closer inspection was indicated. At each point of inspection the soil profile (or cross section through the soil) was exposed by digging with a spade, so that the soil horizons could be examined. The soil was then named and noted on the field map. Whenever a boundary or a change of soil could be detected along the line of traverse it was plotted on the map as observed. If the course of the soil boundaries inside the respective sections could be seen from the lines of traverse they were mapped accordingly. Otherwise the boundaries entering the various sections were joined arbitrarily, similar to the practice followed in contour mapping.

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* Thornthwaite C.W.,"Climates of North America", Geographical Review, October, 1931, Pages 633-655.

The mapping in Townships 1 to 9 in Ranges 4 east and 8 east was done on aerial photographs; the remainder of the area was mapped at an earlier date on township sheets on the scale of two inches to the mile. The detail thus plotted on the photographs and township sheets was transferred finally to composite master maps on the scale of one-half inch to the mile. Reproductions of the final maps (i.e.; Winnipeg Area Map Sheet and Morris Area Map Sheet) accompany this report.

(2) FIELD CLASSIFICATION OF SOILS:

A large number of soils, differing in depth, color, texture, structure, consistency and reaction of their respective soil horizons and in the material on which they were formed, are found within the region covered by this report. Therefore, in order that they can be recognized easily and distinguished one from another, some method of classifying the soils in the field is necessary.

Except in a very detailed survey involving a close examination of every field (and involving time and expense that would not be justified in view of the type of land utilization), it is not possible to show on the soil map every soil unit that could be recognized in each individual field. For practical purposes, in a grain and mixed farming area, it is sufficient to map out as unit areas the portions in which a described or designated soil is the dominant or prevailing type, but in a key to the most important soils it is necessary that attention should be drawn to local soils of different types, which though of minor importance to the area as a whole, may be of considerable importance on an individual property.

A practical field classification of the soils occurring in the Winnipeg and Morris map sheet areas is given in Appendix I. The system of classification therein outlined permits easy identification of the prevailing or dominant soils shown as units on the respective reconnaissance soil maps, and also indicates the soils of minor importance found intermixed with the typical or dominant soils.

B. SOIL DESCRIPTIONS:

(1) GENERAL SOIL DESCRIPTIONS:

The areas covered by the Winnipeg and Morris map sheets may be divided into three "regional soil zones", i.e.; the Blackearth zone, the Grey-Black (or transitional) zone, and the Grey Wooded zone. In each respective soil zone, the typical regional or zonal soil (that has been determined by the regional climate), and the associated local or intrazonal soil types (that have been determined by differences in local soil climates or differences in drainage), that have developed on the same or similar soil parent materials (or geological surface deposits), are designated as a "soil association". The individual associated soils (which are recognized by their profile characteristics) are referred to as "soil associates" each of which, in some countries, would be considered as a "soil series".

The location and distribution of the soil zones, and the various soil units mapped in the Winnipeg and Morris map sheet areas are shown on the reconnaissance maps accompanying this report. These reconnaissance maps should be considered only as schematic presentations of the occurrence and distribution of the predominant soils, because the maps are prepared from observations made along lines of traverse one mile apart. Each group of associated soils shown as a unit on the respective maps is described in general in the subsequent pages. The general soil descriptions in this section of the report are **specifically** presented for local use. For general use, the essential information concerning these soils is summarized and presented as a "Summary Table of Soil Characteristics" in Section (2) which follows immediately after this general descriptive section.

SOILS OF THE BLACKEARTH ZONE:

Typical or zonal Blackearth soils are characterized by a "black" "A" or surface horizon, which is granular in structure, high in organic matter, friable, and generally neutral to slightly alkaline in reaction; and which fades gradually into a lime carbonate accumulation horizon at depths that vary with the parent materials on which the soils are developed. These soils, which occur as the well-drained members or phytomorphic associates on the various soil parent materials in the Blackearth zone, have been developed under tall prairie-grass vegetation, but some tree invasion of prairie has occurred in local sites. The dominant feature of the landscape of the Blackearth zone, in the Winnipeg-Morris map areas, is the broad expanse of prairie which, in general, is broken only by trees and bushes bordering the meandering stream channels. A few small clumps of trees have become established some distance from the streams and, as the Grey-Black transitional soil zone is approached, the tree vegetation becomes more prominent. In some areas the trees have been established long enough to modify the soil profile on which they are supported; this is especially true where mature woods occur as a fringe on the upland adjacent to, and along the margins of the large stream channels.

In addition to the typical zonal Blackearths, a number of intrazonal or local soils occur as occluded or associated types that have developed because of varying degrees of hydromorphism or imperfect drainage. Various degrees of halomorphism or salinization also are encountered as a result of the imperfect drainage. The poorly drained areas in the Blackearth zone are made up largely of Meadow soils. Local areas of Meadow Podzol or Degraded Meadow soils also occur in the eastern portions of this zone. Prior to improvement in drainage by ditching, Peaty Meadow soils were common in the Red River Plain, but the organic mantle of the Peaty Meadow soils is less in evidence now than formerly because much of it has disappeared under drainage and culture, or has been destroyed by fire.

The soils here mapped within the Blackearth zone include, the Red River, Marquette, Fort Garry, Emerson, Lakeland, Sperling, Steinbach, Altona, Agassiz, Kittson, and Springbank soil associations; the Horndean and Woodlands soil complexes; and the Red River - Emerson transitional soils.

RED RIVER ASSOCIATION:

The soils designated as the Red River soil association consist of Blackearth, or blackearth-like and associated soils that have developed on the lacustrine fine clay deposits in the central basin of glacial Lake Agassiz. To understand these soils it should be recognized that all the soils of this association at one time or another have been under the influence of excessive moisture, and (due to gradual improvement in drainage) are now passing slowly through various stages of transition from poorly drained to better-drained conditions. Somewhat more than one-half the area occupied by this association has soils that show the effects of hydromorphism (excessive moisture).

The one outstanding characteristic that the Red River soils have in common is the fine texture of the parent clay but, due to differences in drainage or moisture regime, different soil types with varying morphological features have developed on the same soil parent material. The topography of the clay deposits, in general, is flat and very smooth, and although there is a fall from the western and eastern margins to the Red River channel, and from south to north along the axis of the plain, the grade over much of the area is less than two feet per mile. Portions of the clay plain are exceptionally flat, and before drainage ditches were installed these areas were occupied by broad marshes or wet meadows. Other portions have a micro-relief of low broad ridges and interspersed elongated flats recurring in parallel pattern. These low parallel ridges are the result of lake shore contact, or wave action and undertow, as the waters of Lake Agassiz were retreating during its final stages.

These micro-relief features have had a profound effect on the soils. Although the differences in surface level appear slight, the drainage or moisture conditions within the soils located in the different micro-relief positions vary, and hence the soil climate varies with the variation in soil moisture regime. Consequently the soil-forming processes in the various sites have been affected to the extent that different soil types have been produced.

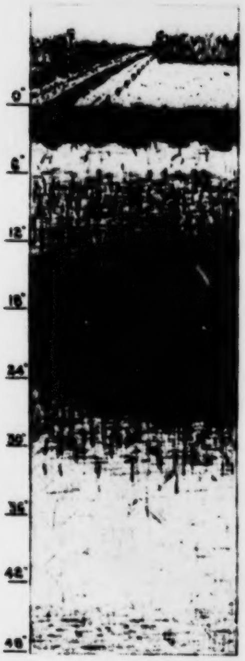
On the somewhat higher and better-drained sites, Blackearth or blackearth-like soils have developed. These soils are characterized by a dark "A" horizon tongued with icicle-like intrusions into a greyish brown clay. The black tongued intrusions are the result of the cracking and shrinkage which is common in these soils during aperiodic dry seasons, and the better the drainage, the more distinct is the brown color of the subsoils. The flat and poorly drained sites are occupied by Meadow soils that are characterized by a relatively thin dark "A" horizon, over a subsoil that is dominantly grey when moist and flecked with limonite (iron) concretions which indicate periodic excessively wet conditions. In the intermediate positions, and between these two soil types, are soils in all stages of transition from Blackearth to Meadow soil that may be classed as Blackearth-Meadow intergrades. These intergrades can be recognized by intermediate depths of dark "A" horizon and a distinctly olive cast in the underlying clay subsoil. Of the soils under the influence of hydromorphism (or excessive moisture) both salinized and nonsalinzed types occur, and in the intermediately drained sites, tough, waxy soil profiles showing alkalinized (or solonetzic) characteristics are widespread.

In the better-drained sites, the soils are approaching equilibrium with the regional climate and, under the regional tall prairie-grass cover, have developed blackearth-like characteristics. However, adjacent to and above the banks of the river channels, where the soil is well drained, an invasion of oak and aspen poplar has formed a fringe of tree growth under which (depending upon the age of the forest) the soils show varying degrees of degradation or modification by leaching, so that degrading Blackearth or Grey - Black soils are in process of development.

In a detailed soil survey, where close examination can be made of each individual field or small holding, the various soil associates of the Red River association could be separated into mapping units and designated by series names, e.g., the well-drained (Blackearth type) soils with brown subsoils could be mapped and referred to as Red River clay; the intermediately drained (Blackearth - Meadow type) soils

Figure No. 16:- REPRESENTATIVE SOIL PROFILES THAT COMPRISE THE RED RIVER SOIL ASSOCIATION

WOODED
P-PHw - Phytomorphic to Phytohydromorphic
ASSOCIATE



0"
6"
12"
18"
24"
30"
36"
42"
48"

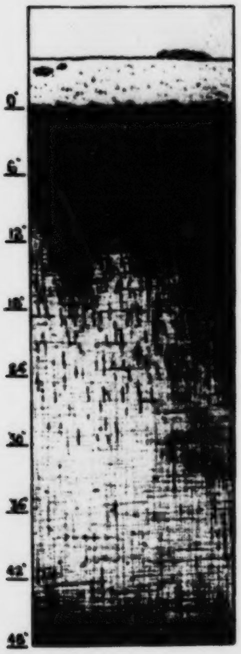
Grey-Black
and incipient
Grey Wooded
Type

WELL DRAINED
P = Phytomorphic
ASSOCIATE

0"
6"
12"
18"
24"
30"
36"
42"
48"

Blackearth
and Blackearth-like
Types

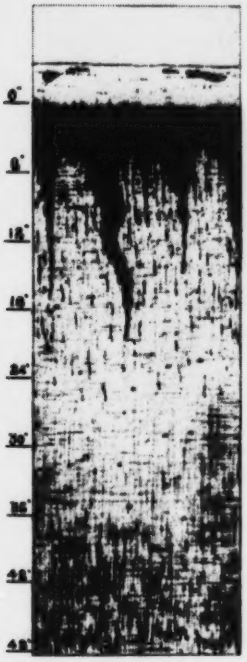
INTERMEDIATELY DRAINED
PH = Phytohydromorphic
ASSOCIATE



0"
6"
12"
18"
24"
30"
36"
42"
48"

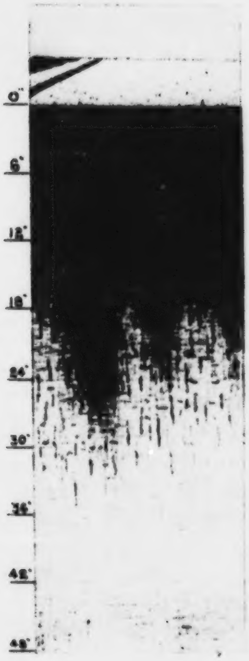
Blackearth - Meadow
Intergrades

POORLY DRAINED
H = Hydromorphic
ASSOCIATE


0"
6"
12"
18"
24"
30"
36"
42"
48"

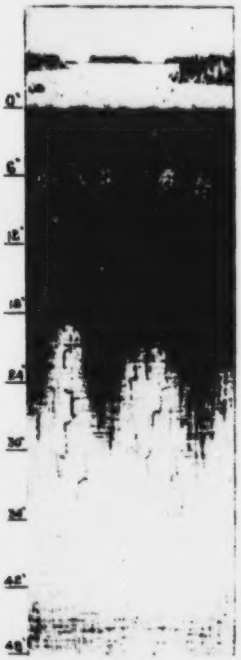
Meadow Soils
(Nonsalinized, Calcic and)
(Salinized Types)

ALKALINIZED
G = Halomorphic
ASSOCIATE


0"
6"
12"
18"
24"
30"
36"
42"
48"

Alkalinized or
Solonetzic
Type

DEGRADED
Gd = Degraded Halomorphic
ASSOCIATE


0"
6"
12"
18"
24"
30"
36"
42"
48"

Solodized-
Solonetzic
Type

could be mapped and referred to as McTavish clay (calcic and noncalcic phases); the poorly drained Meadow type soils could be mapped as Osborne clay (calcic, salinized and nonsalinized); the tough waxy alkalinized (solonetzic type) soils could be mapped and referred to as Morris clay (deep, shallow and degraded phases); and the well-drained wooded (Grey - Black type) soils could be mapped and designated as St. Norbert clay. See Figure No. 16.

In a reconnaissance soil survey however, the soils are observed and mapped from two sides of each quarter section only, and the scale of mapping is too small to permit each soil associate to be shown accurately as a unit area on the soil map. Consequently, in most cases, the unit shown on a reconnaissance soil map is the soil association. In the case of the Red River soil association, however, it was possible to make three main separations and to show, on the reconnaissance soil maps, the location and distribution of the areas where certain soil associates were found to be dominant. Where the well to intermediately drained Blackearth and blackearth-like soils were dominant, they were delineated and shown on the accompanying soil maps as Red River clay, and the occlusion of associated areas of alkalinized (or solonetzic) soils is indicated by standard symbols instead of by soil boundaries. Where the poorly drained Meadow type soils predominate, they are delineated and shown on the soils maps as Osborne clay, and the occlusion of halomorphic associates, or salinized and alkalinized soils, is indicated by standard symbols. Where tree growth has invaded the well-drained sites, and degrading Blackearth or Grey - Black soils prevail, the areas were delineated and designated as St. Norbert clay.

(i) Red River Clay:

The representative blackearth-like soil of the Red River association is the well to intermediately drained associate. This soil is characterized by a black to very dark grey "A" or surface horizon 8 to 12 inches thick, neutral in reaction, rich in organic matter, and with granular microstructure that tends to form columnar aggregates when dry. The "B" or transition horizon is 4 to 6 inches thick, dark greyish brown in color and slightly alkaline in reaction. This horizon grades into a light greyish brown horizon of clay that effervesces feebly with acid. This type is commonly found on the crests of the low clay ridges or adjacent to stream channels where drainage is better than average. (see Figure No. 17.)

The intermediately drained soils constitute a considerably larger portion of the Red River clay area than that covered by the better-drained soils. The typical intermediately drained soil has a very dark grey to black "A" or surface horizon 6 to 12 inches thick, neutral in reaction and with finely granular microstructures that sometimes form slightly solonetzic structural aggregates. This horizon may grade through a lime carbonate accumulation or fade directly into greyish brown clay, amorphous to fragmental in structure, that has an olive cast when moist. In local areas the intermediately drained soils have become more or less alkalinized (or solonetzic) in character, in which case they may be designated as Morris clay. Many degrees of alkalinization occur but it is not practical in reconnaissance mapping to separate out the various intergrades that can be found. (See Figures. No. 18 and 19.)

The representative alkalinized or solonetzic soil associate has a very dark grey "A" or surface horizon, 6 to 10 inches deep, which is tough and compact, and neutral in reaction. This horizon grades into a very dark greyish brown cloddy and somewhat prismatic "B" horizon, 8 to 10 inches deep, which is very stiff and plastic, and dries into extremely hard amorphous clods. Immediately below this horizon, lime carbonate concretions occur in an amorphous dark grey to greyish brown horizon. Some small areas of degrading Solonetz or solodized soils are also found as associates. They are characterized by a greyish, ash-like, slightly acid "A_2" horizon, and very hard round topped columns in the upper portion of the "B" horizon. The solonetzic and solodized associates are most prevalent near Gretna and in the Morris and Brunkild districts. (See Figure No. 20.)

The Red River clay soils are generally utilized for grain production, due in part to the adaptability of these soils to mechanized arable culture, and in part to the fact that, over most of the association, dugouts are the common source of water supply. The Red River soils are highly productive but tillage is heavy because of their fine texture and they generally respond to phosphate fertilizer. The well to intermediately drained soils can be utilized for grains, row crops, grasses, alfalfa and other legumes. The intermediately drained and Solonetz type soils are suited to grain farming providing the soil is maintained in a good workable condition by proper soil management. This includes the return of all combine straw, stubble and barnyard manure (where available) to the land, and crop rotations which provide for periodic production of grasses and legumes to improve internal drainage. The production of root crops constitutes a problem in wet seasons on these soils. If heavy rainfalls occur during the harvest season there is often considerable delay in the harvesting operation, and the removal of earth from roots and potatoes becomes difficult. Improved surface drainage is essential and open drains are needed where natural run-off is not sufficient to remove excess surface water supply.

(ii) Osborne Clay:

The Osborne soils are the Meadow type soil associates of the Red River association. These soils have been developed on flat or depressional topography under meadow or swale grass vegetation. The representative soil has a very dark grey "A" horizon 3 to 6 inches thick, which is rich in organic matter, somewhat granular and friable when moist, lumpy and hard when dry, and usually alkaline in reaction. This horizon is tongued deeply into the underlying soil horizons. A lime carbonate accumulation may or may not occur immediately below the "A" horizon. Where it occurs it is light greyish brown to grey in color, granular in structure, very stickly and plastic when wet, and is flecked by iron staining and concretionary lime carbonate. The subsoil is olive grey to grey clay which is massive in structure when moist but may show fragmental micro-aggregation; plastic and sticky when wet but very hard when dry, and is sometimes moderately high in lime and always iron stained.

Several variations of this poorly drained associate occur. These variations include salinized, slightly alkalinized, and peaty meadow variants. Salinized soils occur frequently on the western side of the Red River but are encountered infrequently on the eastern side of the river. Salts have been carried in by run-off waters from the western uplands where considerable salinity is encountered, and these have been deposited in low areas where the run-off waters ponded and subsequently evaporated. The alkalinized variant often occurs where surface drainage has been improved by open ditches. After a time these soils begin to develop a solonetzic type of profile. However, they are still iron stained in the subsoil. Osborne clay soils with a thin peaty covering (i.e., Peaty Meadow soils) were common under virgin conditions in many sections of the Red River Plain. Most of this peat has been burnt off and at present it is seldom encountered except in the northern and eastern portions of the Red River association. The degree of gleization is dependent upon the soil moisture conditions. The gley horizon is most strongly accentuated where the peaty mantle is present.

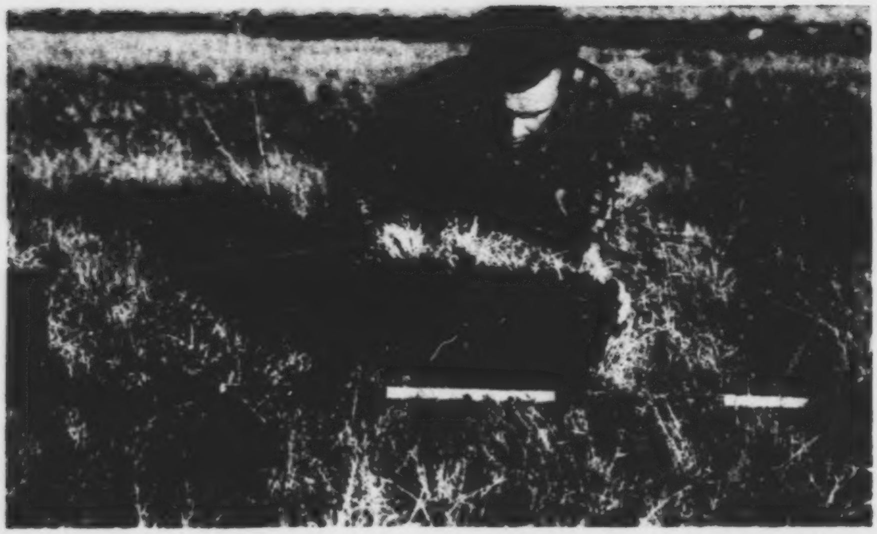


Figure No. 17
Better-drained Red River clay, showing granular structure of the "A" or surface horizon under native grass.

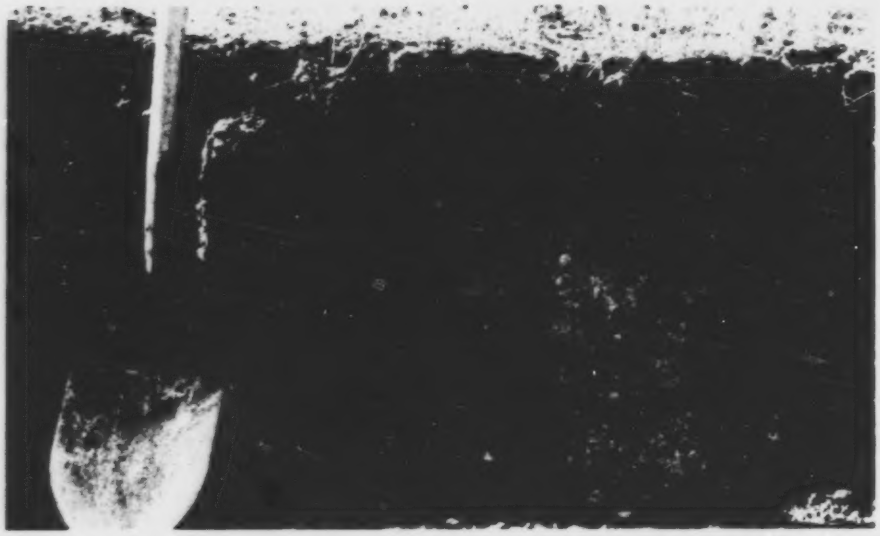


Figure No. 18
Alkalinized or solonetzic associate of Red River clay, showing columnar macrosturctured "B" horizons.

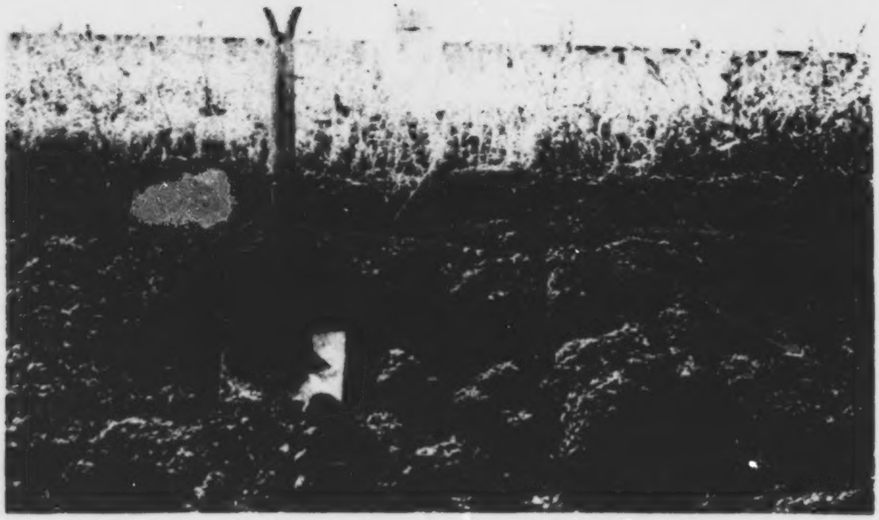


Figure No. 19
Weakly alkalinized or solonetzic associate of Red River clay, showing columnar macrosturctured aggregates disintegrating into hard granular microstructured aggregates as the result of continued exposure to atmospheric weathering.

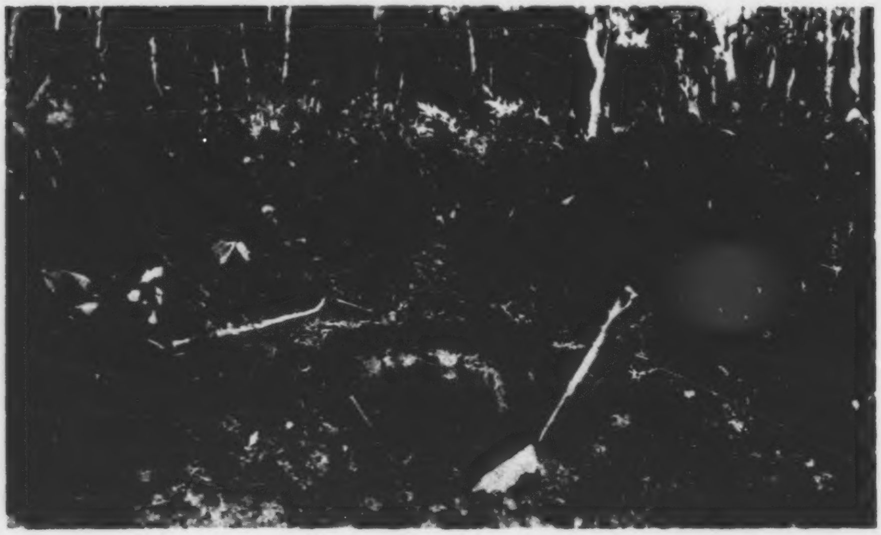


Figure No. 20
Degrading or solodized Solonetz associate of Red River clay, showing white-capped, cloddy columnar structured "B" horizon, and grey ash-like, acid "A_2" horizon. The acid condition which developed as the result of degradation has favored the recent invasion by the young aspen poplar shown in the background.

The Osborne clays or poorly drained soil associates of the Red River association are best utilized for grain or grass hay production. Surface drainage by open ditches is essential as the heavy texture of the soil, together with the flat topography, predisposes to ponding of surface water. Periodic attention must be given to surface drains and ditches to maintain their efficiency, and the filling-in of the drains by soil drift should be prevented by field shelterbelts of tree willows* planted parallel to, and back from, the open drains. The Osborne soils are fairly fertile when newly broken because of the relatively high organic matter content of the surface layer, but under arable culture they soon lose much of this organic matter and crop yields decrease. Under fallow-grain culture, additions of organic matter are required to maintain fertility and soil tilth. This can be accomplished to some degree by the return of combine straw to the soil, by the growing of grasses for hay or seed, and by the use of sweet clover - fallow as a substitute for bare summerfallow. Without adequate drainage the growing of alfalfa and clover is hazardous because the biennial or perennial crops may be drowned out especially in the early spring. Moreover the periodically wet conditions to which the Osborne soils are subjected are not favorable for the production of sugar beets, potatoes, and root crops.

The occluded areas of salinized and alkalinized soils have other specific problems. The salinized soils do not grow as good crops as might be expected in dry years because, with loss of moisture, the soil solution becomes more saturated by salts, and this adversely affects crop growth. The alkalinized soils have poor physical structure which results in a number of problems including, poor germination where the seed bed is poor, root pruning through cracking and shrinkage of the soil in dry periods, and difficult tillage. However, where these problems are recognized, marked amelioration can be expected if suitable soil management practices are introduced.

(iii) St. Norbert Clay:

This soil is the wooded associate of the Red River association. It occurs chiefly along the river channels where woodland invasion of prairie has developed to the greatest extent. The vegetation on these soils is dominantly oak with some aspen and hazel. The better developed virgin soil has a brown leaf mat or "Ao" horizon; a very dark grey clay "A_1" horizon which is up to two inches thick, granular, and neutral in reaction; and a dark grey clay "A_2" horizon which is 1 to 4 inches thick, ash-like and slightly acid in reaction. The "B" horizon is 12 to 20 inches in thickness, cloddy to massive, very hard when dry, plastic when moist, and slightly acid in reaction in the upper portion. Vertical cracking occurs when the soil dries so that it may have a somewhat columnar appearance. The "C_1" horizon is dark brown to dark greyish brown clay which is massive, alkaline in reaction, and contains carbonate concretions.

Many variations in the degree of development of wooded soil profiles exist and all variations between a blackearth soil and the wooded soil profile described above are to be found. Occluded in the St. Norbert soil area are small areas of well-drained and intermediately drained Red River clay profiles.

The wooded soil associates are best suited to the production of grain crops, grasses and legumes. The physical characteristics of the "B" horizon make these soils difficult to till and also make them undesirable for the extensive growing of root crops. The heavy tillage and massive nature of the soil may be corrected to a marked degree by the addition of organic matter in the form of straw or barnyard manure as well as by growing grasses and legumes.

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* See "Farm Forestry and Tree Culture Projects for the Nonforested Region of Manitoba", by Ellis, Gill, Brodrick; Publication Branch Man. Dept. of Agric., 1945.

HORNDEAN SOIL COMPLEX:

The Horndean soil complex consists of a group of relatively immature soils developed on variable textured materials that have been deposited as alluvial sediments, over the Lake Agassiz clay, by run-off waters coming from the higher land to the west. These sediments are the product of sheet and gully erosion that were transported by run-off waters from the benchlands of the Pembina Hills and deposited when the waters spread out or ponded on the flat areas of the Central Lowland area.

The most mature Horndean soils occur on sites where little or no recent flooding has occurred. On these better-drained sites the soils have an "A" horizon, 6 to 15 inches in depth, that is very dark grey in color, prismatic in structure and slightly alkaline in reaction. This horizon grades into highly calcareous, grey, very fine sandy loam to silty clay, which lies over lacustrine deposits at varying depths.

The least mature soils occur as recent deposits where flooding is frequent. Cross sections of these juvenile soils reveal four or more feet of very dark grey alluvial material intermixed with bands of organic residue. This alluvial material is usually clay in texture, but many profiles contain thin layers of somewhat coarser textured materials that range from fine sandy clay loam to silty clay. The clay soils are generally salinized, and in many cases show solonetzic or tough waxy characteristics especially where drainage has been improved.

Varying degrees of soil profile maturity occur between the recent deposits and the most mature Horndean soil. Generally the least mature soils are encountered in the lower positions, and the more mature types occur on somewhat higher topographical positions. Salinization and alkalinization are most pronounced in the clay textured soils.

This complex of soils is best suited to grain production. Artificial surface drainage is a necessity to ensure removal of surplus water derived from heavy summer rains or from spring run-off. The Horndean clay soils tend to become cloddy and tough after artificial drainage is installed. Methods of improving the tilth of these soils include the return of all stubble, combine straw and barnyard manure to the land, as well as introducing crop rotations that include grasses or grass - legume mixtures. The immature poorly drained **Horndean** soils are inferior in productive capacity to the more mature and better-drained soils.

MARQUETTE ASSOCIATION:

The soils of the Marquette association are developed on about 16 to 30 inches of lacustrine clay sediments over till or stratified drift. These soils are located in a transitional position between the soils of the Red River association and soils developed on modified till. Therefore some soils in the Marquette association may resemble soil types of the adjoining associations. Surface textures range from heavy clay loam to clay in texture. The topography of the association is level with some large micro-depressional areas. On the better-drained sites, tall prairie grasses and herbs are normally found but some woodland invasion by aspen has occurred. In many sites, patches of salt-tolerant plant species are found, and in the lower positions, sedges, meadow grasses and willow are the main types of vegetation.

The Marquette association contains three prominent soil associates; namely, the blackearth-like well to intermediately drained associate, the alkalinized soil associate, and the poorly drained or Meadow soil associate.

The dominant well to intermediately drained associate is blackearth-like. It has a very dark grey "A" or surface horison, 8 to 10 inches thick, which is granular in structure, very hard when dry and plastic when moist, and neutral to slightly alkaline in reaction. This horizon fades into a dark brownish grey clay to heavy clay loam "B" horizon, which is prismatic to granular, hard when dry, very plastic when moist, and alkaline in reaction. The "C_1" horizon is brownish grey clay to heavy clay loam, which has a massive structure that breaks down into fine granules, and is mottled with lime carbonate and iron concretions. This horizon is often thin and it may be absent where the lacustrine mantle is shallow. Below the lacustrine material, which is usually 16 or more inches thick, a modified calcareous glacial till occurs. Immediately below the junction of the lacustrine clay and the glacial till, this material is usually stratified, but with increase in depth it grades into unmodified grey mottled till. (See Figure No. 21.)

A more or less Alkalinized or solonetzic soil occurs in association with the well to intermediately drained Marquette clay, and differs from it mainly in the degree of development of solonetzic structure. The alkalinization process however has not progressed far enough to produce a well-developed Alkalinized or Solonetz soil. This type of soil is found in the intermediately drained position usually adjacent to the poorly drained associate.

The poorly drained Marquette soil associate is characterized by a very dark grey "A" or surface horizon 4 to 7 inches thick which is high in organic matter, granular in structure, and strongly calcareous. Below this horizon a sharply defined brownish grey lime carbonate accumulation occurs which is iron stained and usually contains gypsum crystals. The "C_1" horizon is dark greyish brown iron-stained massive clay. At depths seldom exceeding 30 inches, calcareous clay loam to heavy clay loam till is encountered.

The poorly drained soils are usually salinized to some degree, and often salt concentration is strong enough to severely affect plant growth. The profiles whether salinized or not are similar in cross section. In some poorly drained areas a peaty variant is encountered in which the peaty mantle may be up to ten inches in depth.

The well to intermediately drained Marquette soils are suited to the production of general agricultural crops. Root crop production is limited because of the sticky and cloddy nature of the clay soil which causes difficult and late harvesting in wet fall seasons. Periodic grass and alfalfa production, and the return of straw residues to the soil are required to keep the soil porous and friable. Some surface drainage by ditching is necessary on intermediately drained soils to prevent the accumulation of excess surface water. Due to local salinity, good well water may be difficult to obtain, in which case dugouts are generally provided for stock watering purposes.

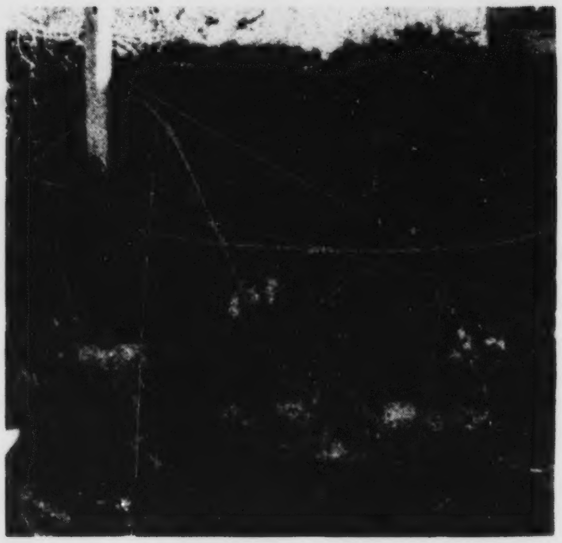

Figure No. 21
Soil profile of Marquette clay developed on a mantle of lacustrine clay over modified calcareous till.

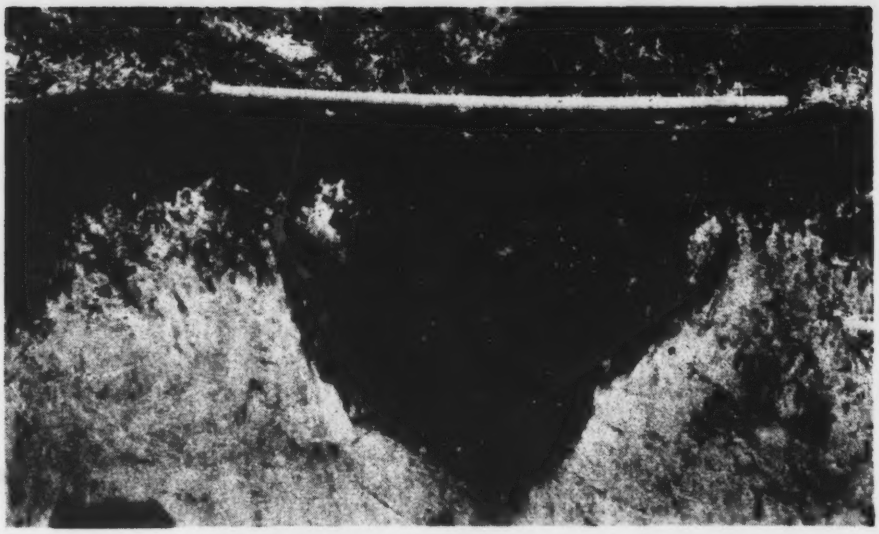

Figure No. 22
Fort Garry clay developed on clay and silty clay mantle over calcareous silty and fine sandy clay outwash with varve clay substrate. The broad-tongued instrusions of surface clay into the calcareous subsoil is characteristic.

The poorly drained soils of the Marquette association are variable in productivity due to the variable degree of salinity. Some of these saline soils are suitable only for hay or pasture. In some areas fair to good grain crops can be grown providing artificial drainage has been installed for the removal of excess surface water. Any peaty mantle which occurs on poorly drained soils that are to be reclaimed for arable culture should be mixed with the top few inches of the underlying clay to improve the workability and porosity of the soil.

FORT GARRY ASSOCIATION:

The soils of the Fort Garry association are developed on a clay and silty clay mantle which lies over strongly calcareous silty and fine sandy clay dolomitic sediments. The clay mantle may be from 6 to 20 inches or more in thickness and it is invariably tongued into the underlying pale yellow material on which it rests. In some areas the calcareous silty materials are confined to low ridges with clay soils of the Red River soil association occupying the intervening positions, whereas other areas are covered completely by the silty deltaic and lacustrine deposits. These deposits, which are up to six or more feet thick, consist of laminated deposits varying in texture from very fine sandy loam to sandy clay and silty clay. Lacustrine clay, generally varved, occurs beneath these silty sediments.

The dominant associate is a blackearth-like soil. In cross section this soil has an "A" or surface horizon which is usually 7 to 10 inches thick but may extend 30 inches downward in large pendulous tongues.* The "A" or surface horizon consists of very dark grey clay to silty clay which may show hard prismatic columns in the tongues when dry, and which is plastic and sticky when wet, neutral to slightly alkaline, and grades sharply into a light grey, friable marly horizon that lies over light grey to pale yellow, laminated, and highly calcareous very fine sand to silty clay. A varved clay substrate occurs at depths ranging from 3 to 7 or more feet. In intermediately drained areas well-developed Alkalinized or Solonetz and solodized Solonetz soils occur, but these types make up only a very small part of the acreage of the association. A considerable acreage of poorly drained or Meadow soil associates occurs in this association, and these poorly drained soils are invariably more or less salinized, and highly calcareous. (See Figures, No. 22 and 23.)

The small areas of the wooded soil associate occur where the better-drained soils have undergone recent invasion by aspen and oak with an undercover of willow, hazel and dogwood. Here the Blackearth profile characteristics have been modified by this woodland invasion and degrading Blackearth or Grey - Black soil associates have developed. On the less well-drained sites, the invading poplar is rarely thrifty, the trees become prematurely decrepid, and are adversely affected by the high lime content and salinity of the subsoils. Although a considerable portion of the Fort Garry soil association is well to intermediately drained, the flat topography, and the mixed textural profile are responsible for poor local drainage. Hence, poorly drained soil associates are scattered throughout.

Due to the proximity of the City of Winnipeg these soils are used for a diversity of crops. Normally, cereals, flax, grasses and alfalfa give good yields except in the saline and more highly calcareous poorly drained soils. A chlorotic condition of certain root and garden crops, and also of trees and shrubs, is commonly observed due to the highly calcareous nature of the subsoil. The chief problems in the management of the Fort Garry soil are, the physical problems connected with surface drainage and with amelioration of the clay surface soil, and the fertility problems of phosphorus deficiency and lime-induced chlorosis that result from the excessive amounts of lime in the subsoil. Nevertheless, with good soil management practices these soils can be made productive; especially if suitable lime-tolerant crops are selected.

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* "The nitrogen content of Red River Valley soils," by Ellis, J.H. and Shafer, W., Scientific Agriculture, Vol. IX, No. 4, Dec. 1928.

RED RIVER - EMERSON TRANSITION:

Where the Emerson association grades into the Red River association, islands of both are found intermixed with transitional types that have characteristics common to both. This mixture of types was mapped as Red River - Emerson transition and should be considered as a complex. The better-drained soils have been classed as Blackearth - Meadow and halomorphic associates, depending upon the corresponding characteristics present; the poorly drained associates are Meadow soils. A small area of Red River - Emerson transition soils is located east of the Emerson association; another area, in which the Red River soils predominate is found between St. Jean and Morris.

The better-drained Red River - Emerson soils are good agricultural land and can be rated as equivalent to, or better than, the Emerson soils. Some areas require drainage by ditches to remove excess surface water.

EMERSON ASSOCIATION:

The soils which have been mapped as the Emerson association are calcic blackearth-like soils, and their associates, which have developed on light grey to straw-colored deltaic silt and lacustrine sediments. These soils occur in the southern portion of the Central Lowlands landscape area. Two textural types are shown on the map, i.e.; silt loam to silty clay loam, and silty clay. These soils are very similar except for differences in texture and minor variations in porosity and friability.

The dominant associate is a calcic blackearth-like soil that is well to intermediately drained. The "A" or surface horizon is 5 to 15 inches deep, very dark grey in color, and silt loam to silty clay in texture. It is friable, granular in structure, and usually contains a high percentage of free lime carbonate. In a wide cross section, the soil shows black tongues intruding into the highly calcareous parent materials. The "A" horizon grades sharply into a well-developed light grey friable "Ca" horizon, which in turn fades into light grey to straw-colored calcareous material that is silty in texture and somewhat iron stained. The silty subsoil is usually moist because of a clay substrate which underlies the silty deposits and retards internal drainage. Following a series of wet seasons, a ground-water table may accumulate above the clay substrate. Lateral and upward movement of this water may result in movement of the soluble salts and lime into the upper part of the soil profile. (See Figure No. 24.)

A few areas of well-drained soils occur in which the soil profile is somewhat deeper than in the intermediately drained associate, and in which a thin greyish brown "B" horizon has developed. A wooded member of the association occurs, usually beside stream channels, where woodland invasion by aspen and oak has taken place. The soil profiles of this associate show variable degrees of development of grey "A_2"

and compact "B" horizons, but no profile can be considered as representative.

Meadow soils or poorly drained associates occur in areas which are depressional in relation to the surrounding terrain. These poorly drained soils are usually salinized to a considerable degree. Both Salinized and Alkalinized soil associates occur in the intermediately drained sites. The Salinized soils cover a more extensive area than the Alkalinized soils and in dry years can be readily recognized in cropped fields by reduced stands and unthrifty growth of grain, and by the presence of salt crystals at or near the soil surface. The Alkalinized soils are not extensive, they occur only as narrow strips or isolated areas adjacent to the depressional positions.

The intermediately drained, well-drained and wooded associates are good for grain, corn, grasses and legumes, because of their friability, porosity, workability and natural fertility. Nevertheless, most of the Emerson soils are calcareous and too alkaline for some fruits and ornamental shrubs. A favourable feature of these soils is the general prevalence of a moist subsoil. The Emerson soils require careful management. The surface soil may be thin due in part to erosion by wind, and the organic matter has been reduced under the fallow-grain system of land use commonly practised. In some years, soil drifting may be quite serious, hence provision for erosion control by the use of crop residues as trash cover and by the growing of fibrous rooted crops is necessary.

The strongly salinized Emerson soil associates have limited agricultural value. However, if adequate drainage can be provided these soils can be improved, so that they can be utilized for the production of grass and legume crops.

LAKELAND ASSOCIATION:

The Lakeland soils are weakly developed calcic blackearth-like soils and associates that have been developed on pale yellow calcareous silty or fine sandy lacustrine and flood-plain sediments. These soils are calcic or high in lime because they have been developed on calcareous parent materials, and they may contain groundwater lime, derived from a water table that may appear periodically above the underlying calcareous till substrate. (See Figure No. 25.)

The terrain occupied by the Lakeland soils has a smooth to very gently sloping topography. Some large areas occur in which the Lakeland soils occupy a depressional position in relationship to the surrounding land. Under such conditions the soils are poorly drained, and in some cases they may have a thin surface deposit of peat. Internal subsoil drainage is impeded in most sites due to an underlying till substrate. However the better-drained soils have sufficient relief to remove excess surface water and in these soils surface drainage is not a serious problem.

This association has been separated into two textural types, i.e.; very fine sandy loam, and clay loams to clays. The fine sandy loams occur most extensively in the Woodlands-Stonewall sub-area, and the clay loams to clays occur principally in the northern extremities of the Red River Plain. The finer textured soils are largely intermediately to poorly drained because of the low position they occupy in relation to adjacent soils, and because of the retarding effect of the till substrate on subsoil drainage. However, where the drainage positions are comparable, the profile characteristics of soils within the two textural types are quite similar except for differences such as texture and porosity.

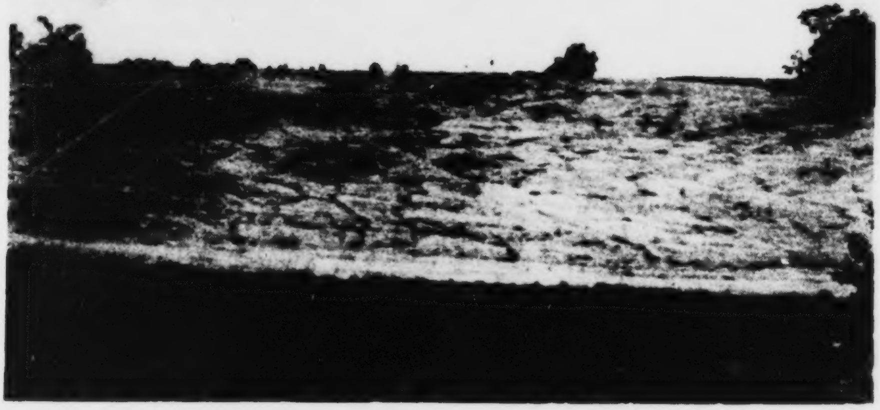

Figure No. 23
Surface appearance of Fort Garry clay, showing hummocks due to the formation of polygons. The rifts between the hummocks correspond with the tongued condition shown in Figure No. 22, and the center of the hummocks correspond with the shallow soil profile shown in the same figure.

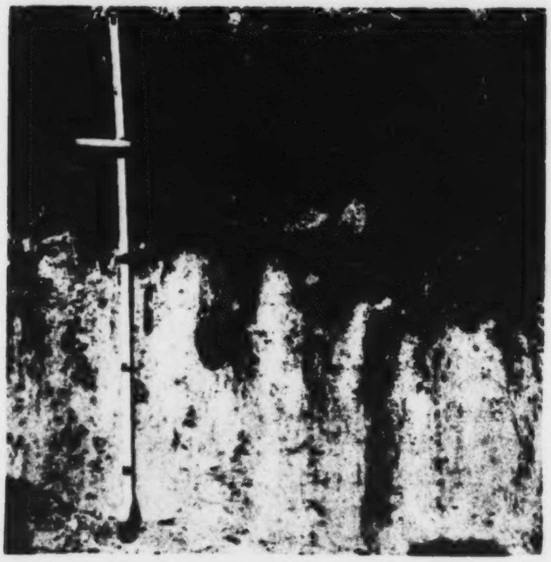

Figure No. 24
Soil profile of Emerson silty clay loam showing dark "A" horizon with lime flecks grading into a marly lime accumulation horizon, above silty light grey to straw-colored deltaic sediment. This profile has been more or less mixed due to the activity of gophers and is under the influence of a moist substrate.

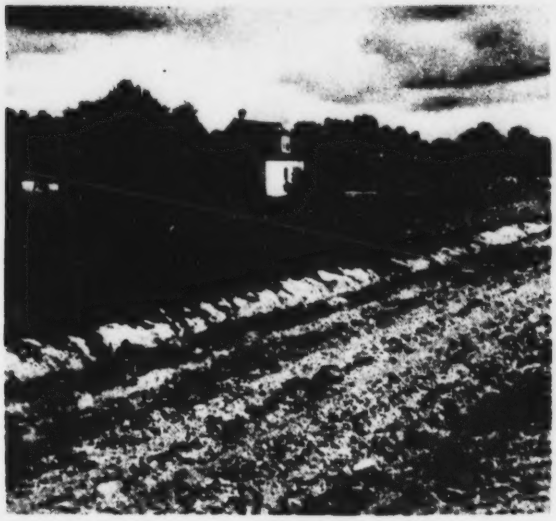

Figure No. 25
Soil profile of Lakeland fine sandy loam lying over till substrate. The tonguing and strong marly lime accumulation are characteristic.

Figure No. 26
Soil profile of Altona sandy loam badly mixed by gophers.
(Measuring stick interval = 12 inches.)

The blackearth-like or well to intermediately drained soil associate has a very friable "A" or surface horizon, that is 5 to 12 inches in thickness, dark grey to very dark grey in color, fine sandy loam to silt loam in texture, and moderately alkaline in reaction. In a few locations a very shallow transitional "B" horizon occurs but generally the "A" horizon grades directly into a very light grey or white lime carbonate layer which may be up to 9 inches in thickness. The lime carbonate accumulation horizon grades into a light grey to pale brown (or yellowish) fine sandy loam to silty loam subsoil. The "C_1" horizon may be thin, but in most profiles a considerable thickness of silty parent material occurs which is highly calcareous, moderately iron stained, and generally underlain by calcareous till similar to the parent material on which the Isafold soils are developed. This till substrate is not part of the Lakeland soil profile, but indirectly it does influence the soil insofar as it affects the water regime by retarding drainage and contributing to the soluble salt and lime content through upward movement of these constituents when ground water is present.

The Blackearth - Meadow or intermediately drained soil associate has profile characteristics which are somewhat similar to those of its better-drained associate. However the "A" or surface horizon is thinner, higher in organic matter, and it usually contains a higher percentage of free lime carbonate.

The poorly drained soil associates often have a shallow covering of muck or peat, over a thin "A" or surface horizon which is high in lime carbonate and organic matter. These soils have subsoil which is calcareous and strongly iron stained. Because these soils occupy depressional positions, they are the recipients of run-off from adjacent uplands. Varying degrees of salinity have developed depending largely on the amount of salt carried in by run-off waters from adjacent areas, and on the degree to which ponding and evaporation has taken place. In some of the poorly drained soil associates, a thin clay layer occurs between the calcareous till and the superimposed deltaic deposits on which the Lakeland soils are developed.

The soils of the Lakeland association are best suited to mixed or diversified farming. The fine sandy loam textured soils are subject to severe wind erosion damage; therefore, livestock production together with the growing of grass-legume mixtures should be the predominant enterprise on these soils. In local sites, the clay loam to clay soils are limited in productivity due to the presence of soluble salts in toxic quantities, but in general, the better-drained soils may be utilized for grain farming. The poorly drained soils are best utilized for hay or pasture and it is only under improved drainage and controlled moisture conditions that these soils will produce satisfactory yields of grain. Salinity is the major limiting factor in the poorly drained soils of both textural types.

There is a general low availability of phosphorus in the soils of the Lakeland association that is caused by the calcareous nature of the parent materials. Phosphate fertilizers are required on cereal and other crops to offset this deficiency. Phosphate deficiency may be noticed in cattle raised on these soils. This can be corrected by feeding the proper mineral supplement and by the application of phosphate fertilizers to the hay and pasture crops.

SPERLING ASSOCIATION:

The Sperling soil association is composed of Blackearth and associated types that have developed on light grey to light yellowish brown sediments which have been transported by the Boyne Creek from the lower Assiniboine delta. The sediments are levee and overwash deposits along the banks of this intermittent stream where it flows over the clays of the Agassiz basin. The Sperling soils extend from Carman (on South-Central sheet) to Sperling in a strip that is no more than three or four miles wide. Meandering dry stream channels, that fade out in the eastern portion, can be traced through this area. Near the stream channels the levee deposits may be 7 to 10 feet in thickness but these sediments gradually become thinner with increasing distances from the channels. Near the outer boundaries of the Sperling soils the superimposed materials are thin and may not exceed one or two feet in depth. A buried soil, similar to the Osborne clay in character, can be found below the Sperling parent material. However, fairly typical Blackearth soils have been developed on the levee deposits indicating that the parent materials of the Sperling soils have been in position for a sufficient length of time to permit the establishment of Blackearth profiles.

The texture of the sediments on which the Sperling soils have been developed varies from west to east and from the stream channels to their margins. The surface soil tends to be fine to very fine sandy loam in the western and central portions of the association (which occur in the South-Central map sheet), but towards the eastward margin of the Sperling soil association the texture gradually becomes finer and grades through silt loam, and clay loam, to silty clay, which are the predominant surface textures of these soils in the Winnipeg map sheet.

The Sperling soils have developed, under tall prairie grasses and herbs with some associated meadow grasses, on smooth topography and under good surface drainage. The dominant soil has a very dark brown to black "A" or surface horizon, 10 to 16 inches thick, ranging in texture from fine sandy loam to silty clay, finely granular in structure, friable, and slightly alkaline in reaction. The "A-B" or transition horizon, if present, is thin and poorly developed. The "A" or "A-B" horizon where present, grades into a light grey lime carbonate horizon which in turn fades into a light grey to light yellowish brown "C_1" horizon.

The Sperling soils are excellent for agricultural purposes and suited to the production of cereals, of intertilled crops such as corn and sugar beets, and of grasses and legumes. Soil drifting occurs unless preventative measures are adopted. Flooding due to overflow and outwash from the Boyne Creek, is an occasional hazard. The Sperling soils can be maintained at a high level of productivity if good cultural practices are followed.

STEINBACH ASSOCIATION:

The Steinbach soil association is composed of blackearth-like slightly degrading blackearth-like and associated types, developed on a relatively thin mantle of sandy flood-plain deposits superimposed over fine lacustrine sediments which lie over a substrate of calcareous till. The Steinbach soils were developed under meadow and tall prairie grasses, but recently they have been modified to some extent by woodland invasion. This association occurs in the western portion of the Central Lowlands, adjacent to the higher lands of the South-Eastern lake-terrace region. Run-off waters from the higher land to the eastward tend to keep the subsoils moist and carry in lime carbonate and small quantities of soluble salts.

The dominant soil is the intermediately drained or Blackearth - Meadow soil associate. It has a very dark grey "A" or surface horizon, which is 6 to 12 inches thick, medium granular in structure, very friable, moderately alkaline and fine sandy loam to fine sandy clay loam in texture. This grades sharply into a very light grey to white lime accumulation horizon, which in turn fades into iron-stained, light brownish grey to pale yellow variable textured deposits. These deposits are generally composed of stratified sandy materials but thin bands of finer sediments often occur. These stratified materials usually rest on a thin layer of lacustrine clay with a substrate of calcareous till. Consequently internal drainage is retarded.

The Steinbach soil associate which has been modified by woodland invasion is neutral in reaction. This soil has a perceptible grey "A_2" horizon, and a somewhat nuciform or nutty structured "B" or illuvial horizon. This wooded soil associate is confined to local sites of very limited size.

The poorly drained or Meadow soils occupy only a small percentage of the total area in this association. They commonly occur as islands in the mirco-relief depressions and they are generally calcareous and sometimes salinized. Salinization in these soils is due, in part, to the salts which are carried in by water flowing from some of the many artesian wells which occur in this area, and in part to seepage from adjacent areas combined with imperfect internal drainage.

The soils of the Steinbach association are suitable for general agricultural use. The moist subsoils, caused by the retarding effect of the finer textured substrate on internal drainage, result in a favorable moisture regime in the drier years; in wet years drainage may be required. The lime content is generally unfavorable for the horticultural crops that require an acid medium, but most vegetables thrive if the land is suitably manured and fertilized. Suitable land management practices are needed to control wind erosion. The poorly drained Meadow soil associates require drainage.

ALTONA ASSOCIATION:

The Altona soils are developed on sandy to silty lacustrine and deltaic sediments with smooth very gently sloping topography, and under the influence of tall prairie-grass and meadow-grass vegetation. The prevailing Altona fine sandy loam soil has a well-drained profile with a moist substratum. The "A" or surface horizon is very dark grey in color, fine sandy loam to very fine sandy loam in texture, and has a weakly developed crumb structure that slacks readily. The "A" horizon is porous, friable, neutral to slightly alkaline in reaction, and 10 to 20 inches thick. The "A-B" or "B" transition horizon is grey brown to light yellowish brown in color, usually structureless, loamy fine sand to very fine sandy loam in texture, extremely friable, porous and moderately alkaline in reaction. This horizon ranges in thickness from 7 to 14 inches. Below this layer is a carbonate horizon 8 to 15 inches thick, and this in turn is underlain with a light yellowish brown fine sand to very fine sandy loam subsoil. In some locations a clay textured substrate occurs at shallow depths, but usually the sandy deposits over the clay are several feet in thickness. The better-drained Altona soil profiles are often mixed from the burrowing of rodents so that differentiation of horizons is difficult. (See Figure No. 26.)

The soils of this association have been separated and shown on the soil map as two textural types; i.e.; Altona fine sandy loams, and Altona fine sandy clay loams. These soils are similar except for differences in texture. The sandier types are located at somewhat higher elevations in the western portion. The finer textured types are generally not as well drained as the fine sandy loams, but they have more strongly developed structural aggregates. The parent materials become shallower in depth and finer in texture in the eastern portion of the area occupied by this association.

The surface drainage of the Altona soils is good and the soils are porous, but a fluctuating water table may be present below the soil profile. The fertility is naturally good, however on many of the cultivated fields the productivity has been markedly reduced by the removal of organic matter by wind. In the early years of settlement these soils were used extensively for wheat production, but in recent years, corn, sunflowers and other intertilled crops are being used as fallow substitutes. Legumes and grass-legume mixtures, manures and trash cover should be used more extensively to maintain the organic matter of the soil. Trees thrive except where drainage is poor or where the rise of ground water may bring soluble salts and lime from below. On the representative soils, field shelterbelts should be used systematically to provide protection from wind. Trash cover also should be used to check.soil drifting. The Altona soils are good for general agricultural purposes, and especially for the production of corn, fruit, and canning garden crops. The soils are easily worked, growth on them is early and rapid, but they require careful handling if productivity levels are to be maintained and soil drifing controlled.

AGASSIZ ASSOCIATION:

The Agassiz soils are coarse textured Blackearths developed on the gravel and coarse sandy beach deposits of glacial Lake Agassiz. Small areas of similar gravelly soils developed on kame-like deposits and other forms of outwash are included in this association. These soils are invariably coarse textured. They have developed under a vegetation of mixed prairie grasses and herbs; occasionally scrubby poplar and oak may be found along the margins, but rarely on the crests of the beaches. The well-drained soil associate has a thin dark grey coarse loamy sand to sandy loam "A" or surface horizon that is 4 to 8 inches thick, structureless, loose and slightly alkaline in reaction. The "B" or transitional horizon is a dark brown to brownish grey loamy coarse sand to coarse sandy loam layer, that is 3 to 7 inches thick and moderately alkaline in reaction. A somewhat indurated accumulation of lime carbonate occurs below the "B" horizon and grades into a gravelly or sandy substratum that is water worked and stratified. The Agassiz soils are easily recognized as a complex of variable textured surface soils over gravel and sand in the form of ridges. Due to the rounded ridge-like surface, and to the coarse textured porous materials, the upper portion of the Agassiz soils is excessively drained, but a wet substratum may be present below the soil profile.

These gravelly soils are of little value for arable culture. They may be used for pasture; however, their carrying capacity is low. The material is generally an excellent source of gravel for road ballast and for building purposes. (See Figure No. 27.)

KITTSON ASSOCIATION:

The Kittson soil association is comprised of Blackearth, degrading Blackearth, and associated soil types, which have been developed on shallow, sandy, reworked sediments that rest over a stony calcareous till substrate. A gravelly or cobbly lens is often present at the junction of the sandy mantle and the underlying till. The vegetation was originally tall prairie grasses, but woodland invasion by aspen and some oak has taken place. There is an over-all gentle upward slope from west to east interrupted only by undulations of the basal glacial drift or subaquatic till that have been smoothed over by the action of lake waters. Local relief is encountered in the western portion where the till and superficial deposits have been dissected by streams.

The Kittson soil association has been divided into two phases, i.e.; the shallow phase and the deep phase. The separation was based on the thickness of the sandy sediments overlying the till. The shallow phase Kittson soil has developed on a sandy mantle, less than 15 inches in depth, over till; and the deep phase Kittson soil has developed on a sandy mantle, approximately 16 to 30 inches in depth underlain by till. The two phases have different land-use capabilities.

(i) Kittson Soils, Shallow Phase:

The shallow phase Kittson soil is most prevalent near the western margin of the area covered by the Kittson association. This phase usually occupies the locally elevated sites. The soils are dominantly imperfectly drained and more or less stony. A large portion of the soils is covered by aspen and willow, and modification of the soils by woods has taken place locally.

The "A" or surface horizon of the well to intermediately drained soil is 3 to 4 inches thick, very dark grey in color, fine sandy loam to fine sandy clay loam in texture. This friable, medium granular, slightly alkaline horizon grades into a dark grey "B" or transition horizon 5 to 8 inches in depth which is friable, granular in structure, and alkaline in reaction. A sharply defined lime carbonate horizon 4 to 6 inches deep occurs immediately below the "B" horizon. The horizon containing the lime carbonate accumulation is often gravelly or cobbly and stratified, but this type of modification of the glacial till fades out quickly with increase in depth. (See Figure No. 28.)

Soils of the Kittson association shallow phase include wooded, intermediately and poorly drained associates. The wooded soil associate has a profile somewhat similar to the well to intermediately drained associate described above, but due to the influence of woodland invasion, this associate has a slight greyish leached "A_2" horizon, and a more compact illuvial "B" horizon. Moreover the "A" and "B" horizons are less alkaline. The intermediately drained soil associate shows little or no "B" or illuvial horizon, and the surface horizon is generally finer in texture and higher in lime carbonate than the better-drained soils. The poorly drained or Meadow soil associate are predominantly mucky, and saturated with lime throughout the profile. Meadow Podzols or leached Meadow soils also occur in some depressional positions.

Land-use practices in the shallow phase Kittson soils are governed by the degree of stoniness. Generally this association of soils is suited mainly to livestock production, but the soils that can be tilled are moderately productive for grain and hay crops. Wind erosion control, maintenance of organic matter, and stoniness, are the main problems in the management of land under arable culture. The nonarable lands are best utilized as woodlots and native pastures. The intermediately and poorly drained soils are calcareous so that plants are subject to physiological drought in dry years and this may reduce crop yields. The poorly drained Kittson soil associates are best utilized for hay and pasture.

(ii) Kittson Soils, Deep Phase:

The deep phase Kittson soils are most prevalent near the eastern margin of the area covered by this association. Seepage water from the higher lands to the east, and impeded internal drainage caused by the till substrates, are responsible for the predominant imperfect drainage and moist subsoil conditions which occur in this area. Woodland invasion of prairie has taken place to such a degree that large portions of the association have become covered by aspen, however only in the better-drained sites has slight modification of the soil profile by degradation under woods occurred. The stones in the underlying till are usually covered by the sandy mantle so that they do not affect tillage, but in local areas, the larger stones may occur as intrusions into the surface soil horizons.

The well to intermediately drained and deep phase, Kittson soils have a very dark grey "A" or surface horizon that is 5 to 8 inches thick, very friable, fine sandy loam in texture, and neutral in reaction. The lower part of this horizon is often lighter in color which can be taken as an indication of an early stage of degradation. The "B_2" horizon of these soils shows some compaction and is granular in structure, slightly cemented when dry, and neutral to slightly alkaline in reaction. This horizon grades through a light greyish brown "B_3" horizon, which is loamy fine sand in texture, very friable, and alkaline in reaction, into a distinct horizon of lime accumulation. This carbonate horizon blends into very pale brown sand, or grades sharply into the till substrate depending on the depth of the surface mantle. A gravelly or cobbly lens is commonly present at the junction of the sandy mantle and the underlying calcareous till.

Soil types found in association with the "well to intermediately drained" associate include wooded, intermediately drained, and poorly drained soil associates. The wooded soil associates show a moderately developed "A_2" or leached horizon, and a well-formed "B" or illuvial horizon. This type occurs as a local soil in the well to intermediately drained soil areas. The intermediately drained or Blackearth - Meadow soil associates have little or no "B" horizon, but the "A" or surface horizon of these soils may be up to 15 inches in thickness, rich in organic matter, and moderately high in lime. Some intermediately drained soil profiles show slight degradation as the result of woodland invasion. Large areas within this soil association are poorly drained. These poorly drained soils are of three types, i.e.; Meadow soil, Peaty Meadow soil and Meadow Podzol. The respective "A" horizons in the Meadow and Peaty Meadow soils are relatively thin and are usually calcareous.

From a land-use standpoint a livestock enterprise is desirable on the deep phase Kittson soils so that nonarable areas may be utilized to best advantage. Grain can be grown on the better-drained soils if care is taken to preventsoil erosion and to maintain the supply of organic matter. The deep phase Kittson soils are suitable to grass and legume production and these crops should be given a prominent place in the crop rotation. The poorly drained or Meadow soil areas are more suitable for use as hay or pasture land, but under favorable conditions these areas may be utilized for grain growing and general agriculture if adequate drainage can be provided.

SPRINGBANK ASSOCIATION:

The Springbank soil association consists of Blackearth and associated soil types which have been developed on sandy outwash or shallow lacustrine sediments under tall prairie-grass vegetation. These soils are located in the depressed sections and along intermittent runways near the southwestern margin of the South-Eastern (lake-terrace) Complex. The parent materials of these soils were deposited as outwash material from runways which originate in the higher land to the east and as "lacustro-littoral" deposits in glacial Lake Agassiz. A calcareous till substrate occurs at depths of 30 inches or more. A gravel or cobble lens and in some places a thin fine lacustrine layer may occur at the junction of the sandy mantle and the underlying till. In some places the topography is smooth, very gently sloping, but in other sites stronger relief is encountered due to dissection by intermittent runways. Woodland invasion of prairie has caused a slight degradation of soils in localized areas.

The Springbank well to intermediately drained associate is a deep blackearth-like soil with a fine sandy loam surface texture.* The "A" or surface horizon is 7 to 12 inches thick, very dark grey in color, friable and slightly alkaline. An equal thickness of very dark brown to greyish brown "B" or transitional horizon usually occurs which has little or no structure, but is fine sandy loam in texture, very friable, and slightly alkaline in reaction. The "B" horizon grades sharply into a lime carbonate layer which is 4 to 10 inches thick and fine sand in texture. This horizon is underlain with a pale yellow to a yellowish brown calcareous fine sand, which is generally superimposed on very pale brown calcareous till at 30 or more inches. Slight iron staining is commonly present at the junction between the sand and the till substrate. (See Figure No. 29.)

The Springbank intermediately drained or Blackearth - Meadow associates, have slightly thinner soil profiles and are more alkaline than their better-drained associates. They contain more iron, and carbonate concretions occur in the subsoil. The Springbank poorly drained associates are of the Meadow soil type. Meadow soils with somewhat mucky surface horizons, and Peaty Meadow soils are the most common. Meadow Podzols occur in some depressional sites, but they are less common than the Meadow and Peaty Meadow soils.

From an agricultural standpoint the better-drained Springbank soils have a wide range of possibilities. The soils are fertile and with good management can be farmed successfully. Grass-legume crops in rotation with grain, the use of fertilizer, and cultural practices which provide for moisture conservation and control of wind erosion are essential procedures. In dry years, erosion by wind can be very severe. The clods formed under moist conditions are readily pulverized to single grains, so that the soil will move quite easily with only moderate winds. Hence, the growing of grass and the use of trash cover for wind erosion control are essential in a good soil management program for these soils. The poorly drained soils may be used for arable culture if drained, however these areas are small and they are best used for hay and pasture.

WOODLANDS SOIL COMPLEX:

The Woodlands soil complex consists of shallow calcic blackearth-like or rendzina-like (high-lime) soils which have developed on shallow lacustrine sediments over modified calcareous boulder till. The depth of the water-laid sediments varies from 0 to 24 inches and therefore, in many cases, the soil profile is developed either completely or partially in the boulder till. The water-deposited sediments are similar to those encountered in the Lakeland association and the boulder till is similar to that on which the Isafold soils are developed. The Woodlands soil complex includes all transitional soils between the Lakeland and Isafold associations, and also contains small occluded areas of these two soils. The degree of surface stoniness is variable depending upon the proximity of the underlying stony till to the surface. (See Figure No. 30.)

The level to smooth very gently sloping topograph which prevails, results in imperfect to poor surface drainage, and the boulder-till substrate impedes internal drainage. The soil water is highly charged with lime and as internal drainage is poor

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* The well-drained soils of the Springbank association, that have developed where the sandy mantle extends for some depth below the soil profile, resemble and may be correlated with the Blackearth associates of the Altona soil association.

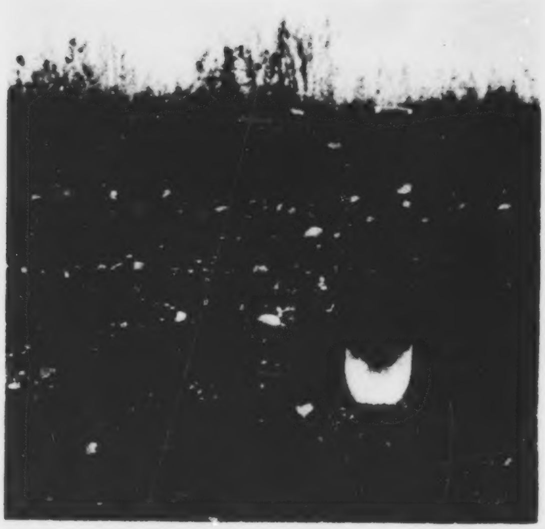

Figure No. 27
Soil profile of Agassiz coarse sandy loam
over stratified gravel.

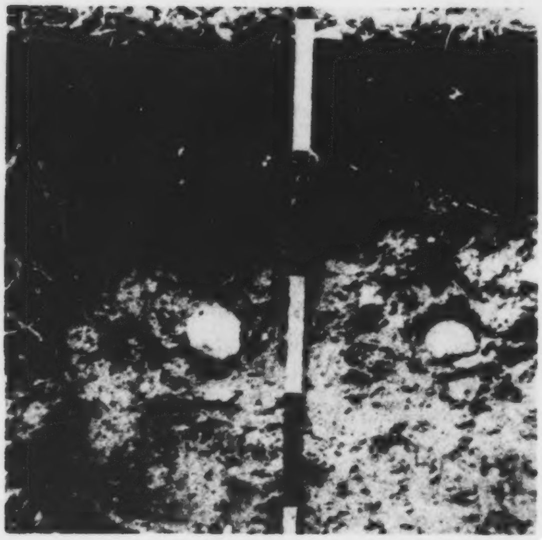

Figure No. 28
Soil profile of Kittson phytomorphic associate,
shallow phase. Fine sandy loam mantle over
boulder till.
(Measuring stick interval = 6 inches.)

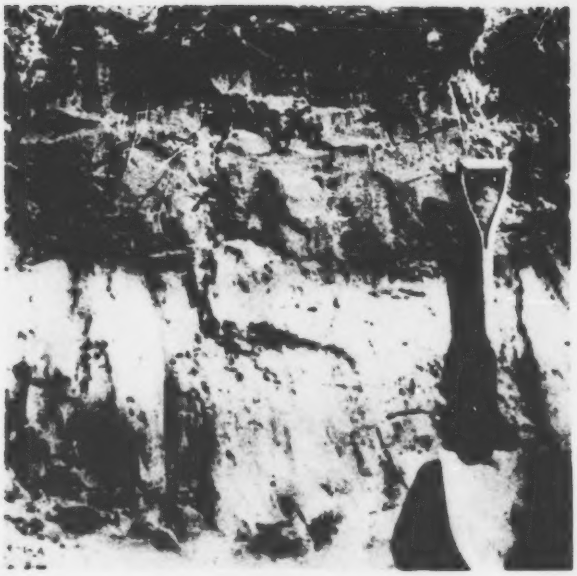

Figure No. 29
Soil profile of Springbank fine sandy loam.
Well to intermediately drained associate.

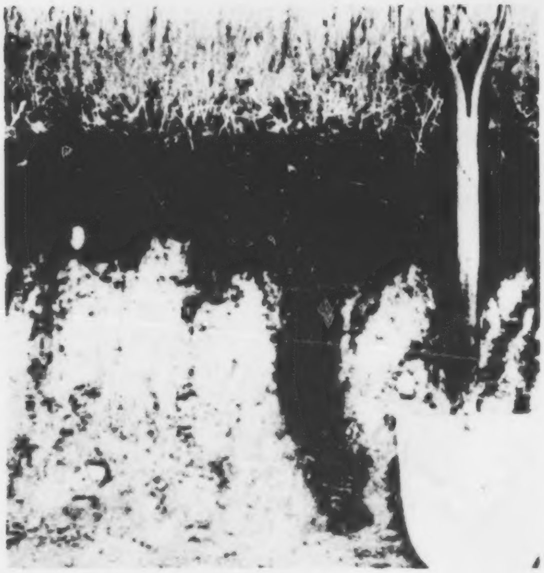

Figure No. 30
Representative soil profile Woodlands complex.

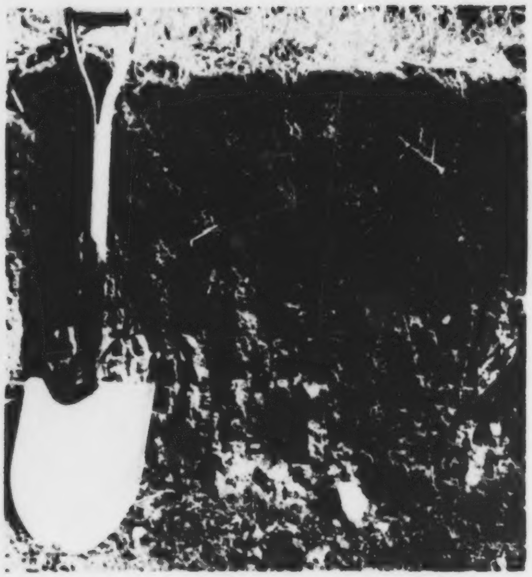

Figure No. 31
Soil profile of Peguis clay. Grey-Black or degrading Blackearth developed on lacustrine clay with a till subsoil.

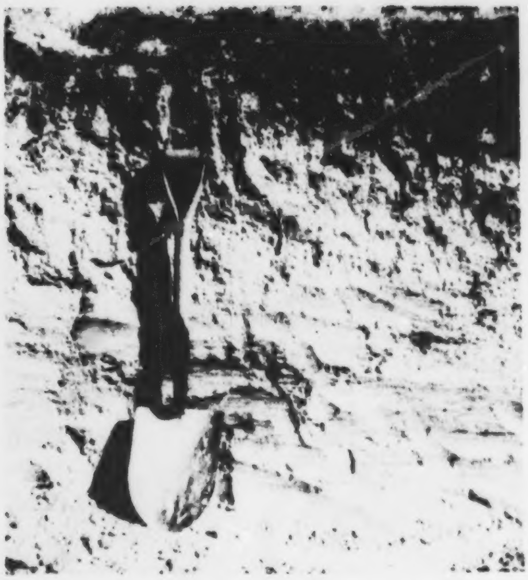

Figure No. 32
Soil profile of Zora silty clay loam. A degrading Blackearth on water-laid sediments with a till substrate.

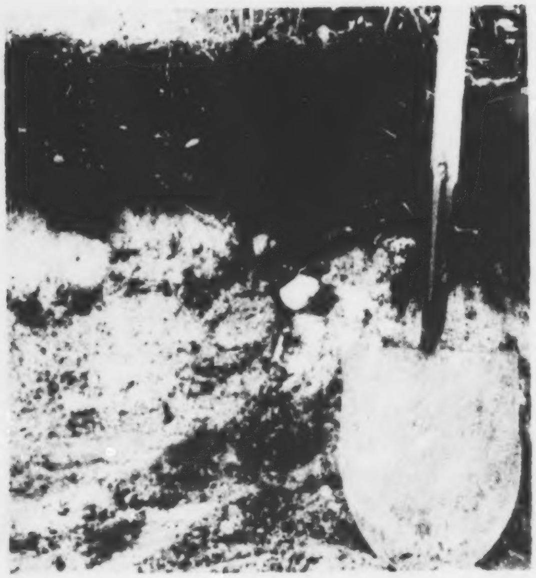

Figure No. 33
Soil profile of Semple clay. A degrading Blackearth developed on thin clay mantle over calcareous till.

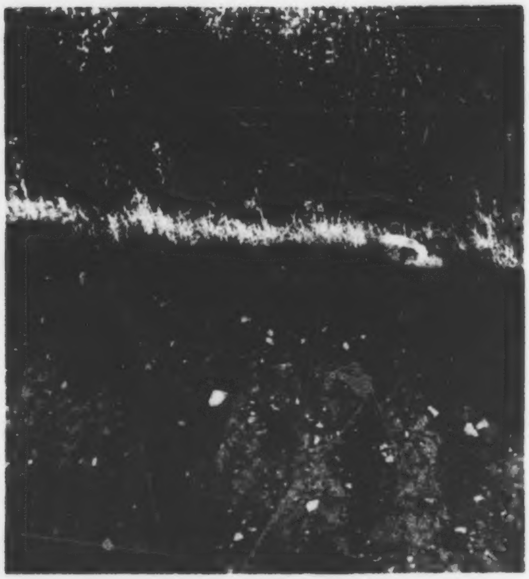

Figure No. 34
Soil profile of Pelan shallow phase. Grey-Black soil developed on thin sandy mantle that is more or less separated from the underlying till by a gravel or cobble lens.

the profile is invariably saturated with carbonates. The vegetation is largely mixed meadow and prairie vegetation but islands of aspen, willow, and occasionally oak occur on the low knolls.

The representative intermediately drained soils of this complex have a dark grey "A" or surface horizon which is fine sandy loam to silty clay loam in texture, friable in consistence, and moderately calcareous. The "B" or transition horizon, where present, is very shallow and grades into a strong lime carbonate accumulation. The soil profiles have very similar soil horizons, except for texture, whether they be developed on modified till, lacustrine sediments, or on a combination of till and lacustrine sediments. However, one variable feature is the occurrence of a gravel lens at the junction of the till and the water-deposited sediments, and as the depth of the lacustrine sediments is variable, this gravel lens may occur at varying depths within the different soil profiles. Where it occurs at very shallow depths, the limestone gravel apparently limits the depth of profile development, in which case the gravel lens and the lime carbonate accumulation appear at the base of the "A" horizon.

A somewhat better-drained soil type occurs within the intermediately drained areas. This soil is slightly deeper than the intermediately drained soil, and it does not have a strong marly lime accumulation horizon although free lime carbonate generally occurs throughout the profile. The Meadow or poorly drained soil associate has a 4 to 7 inch grey "A" or surface horizon, that is definitely calcareous and grades into a marly accumulation which often contains soluble salts.

Mixed farming, with major emphasis on livestock production, is the type of agriculture best suited to soils of this complex. During the survey, fair to good grain crops were seen on summerfallow but grain crops on second-crop land were poor. Physiological drought and fertility appear to be limiting factors. Grass-legume crops are essential to maintain organic matter. Phosphate fertilizers are required to offset low availability of phosphorus in the soil, and barnyard manure has a high fertility value when applied to these soils. It may be noted however that some areas are either too stony or are too saline to be used as arable land in which case they are best utilized for hay and pasture. Provision for adequate surface drainage is needed generally.

SOILS OF THE GREY - BLACK ZONE:-

The Grey - Black soils occur as well-drained representative members of a transitional belt of soils between the Blackearth and Grey Wooded soil zones, and in addition, Grey -- Black soils or degrading Blackearths occur as associated local soils in adjacent soil areas within the Blackearth and the Grey Wooded soil zone. Grey - Black soils can be considered as a group which represent all transitional stages of profile development between Blackearth soils, developed under grassland vegetation, and Grey Wooded soils developed under forest vegetation. These Grey - Black (or degrading Blackearth) soils were originally developed under grassland vegetation and originally had Blackearth characteristics, but forest invasion of grassland has advanced to a point where the soils now show varying degrees of degradation. The "A" or surface horizon of these soils shows varying degrees of transition from black to grey black or grey, (a grey black mottling is quite common), and is neutral to slightly acid in reaction. The "B" or illuvial horizon tends to be nutty in structure, and the aggregates more or less coated with humus that has leached from the "A" horizon. The lime carbonate below the "B" horizon is concretionary and usually well defined, but it occurs at greater depths than in the corresponding adjacent Blackearths.

In the Grey - Black (or degrading Blackearth) transitional soil zone of the Winnipeg-Morris map areas, large areas of intrazonal soils may occur in association with the Grey - Black soils, especially on sites where the topography is nearly level and the internal drainage of the soil is impeded. In the hydromorphic sites of this transitional soil zone, the soil climate is conducive to the formation of Peaty Meadow soils, but Meadow and Meadow Podzol soils also occur in minor areas. Little or no salinity is normally encountered in locally humid soils of this transitional zone. The poorly drained soils are usually developed under meadow-grass vegetation whereas trees are the dominant vegetation on the better-drained sites.

The soil associations occuring as members of the Grey - Black transitional zone in the Winnipeg-Morris map areas include the Peguis, Zora, Semple, Pelan, Poppleton, Tolstoi, and Leary soil associations.

PEGUIS ASSOCIATION:

The Peguis soil association consists of soils in the Grey - Black transitional zone which have been developed, under forest invasion of grassland. on clay that is underlain with calcareous till at depths ranging from 16 to 30 inches. The clay sediments are a part of the clay plain laid down in the waters of glacial Lake Agassiz. The parent material of this association is similar to the parent material of the Marquette association which occurs in the Blackearth zone, but the profile of the well-drained Peguis soil is degrading due to the effects of forest invasion. This soil association is limited to an area of approximately 12,000 acres, all of which occur on the Winnipeg map sheet.

The representative degrading Blackearth soil in this association is well to intermediately drained. It has an "A_o" horizon which is a dark brown leaf mat, neutral in reaction, resting on an "A_1" horizon that is very dark brown in color, 1 to 2 inches thick, and neutral to slightly acid in reaction. This grades into an "A_2" eluvial horizon consisting of dark grey clay, 2 to 4 inches in depth, granular in structure, and slightly acid in reaction. The "B" or illuvial horizon is 7 to 8 inches thick, with a somewhat cloddy to columnar macrostructure that breaks into nutty aggregates, very plastic when moist, and neutral in reaction. This horizon fades into a slightly iron-stained greyish brown clay, that is granular in structure, 6 to 18 inches thick, and moderately alkaline in reaction. The clay is superimposed over an unrelated substratum, which may consist of either till or modified till. (See Figure No. 31.)

The intermediately drained soil associate has a mottled subsoil and a thinner "A" or surface horizon than the better-drained soil. More degradation is encountered in these soils around the edges of poorly drained depressions. The poorly drained Meadow associate has a thin "A" horizon seldom exceeding 4 inches, and an iron-stained "G" or gley horizon immediately below the "A" horizon. The "C_1" horizon is a moderately calcareous grey clay. Peaty Meadow soils on which the peat may be up to 10 inches thick, are frequently encountered in the poorly drained depression.

The better-drained Peguis soils are well adapted to both wheat and coarse grain production as well as for the production of grasses and legumes. They can be used also for the production of hoed crops such as potatoes or sugar beets. The productivity of the Peguis soils is somewhat better than in the Red River soils because they are neutral in reaction and thus provide a better medium for plant growth. The periodic application of manure, and the production of grass and legume crops, would improve the workability of these soils. The Meadow soils require the installation of surface drains as the initial stage in reclamation.

ZORA ASSOCIATION:

The Zora soil association consists of wooded blackearth-like and associated soils, which have developed under imperfect drainage in the Grey - Black soil zone, on water-laid sediments that occur as a mantle 2 to 6 or more feet in depth, over a glacio-lacustrine or a till substrate. The water-laid sediments are generally silty, but the textures range from sandy loam to silty clay. These soils are more or less under the influence of imperfect drainage due to the flat topography and to the heavy textured substrate which prevails and impedes internal drainage. In these soils, Grey - Black morphological characteristics are feebly expressed or absent because the degrading process has been retarded by the imperfect drainage and by the high lime content of the ground water. Originally poorly drained areas in this association were covered largely by peat. The peaty areas have been reduced considerably in extent as the result of drainage by open ditches, and by burning of the peat. Drainage and removal of the peat by burning have profoundly altered the soil climate, and thus affected the soil-forming processes and land-use capabilities. Many areas, which originally were Half-Bog or Bog, now must be classified as calcareous Meadow soils.

The Zora soils have been separated and mapped as two textural types. The surface textures of one type, range from sandy loam to very fine sandy loam; and surface textures of the other type, range from loam to silty clay. Under similar conditions, the sandy textured soils show a greater degree of profile development than the finer textured soils. (See Figure No. 32.)

The well to intermediately drained Zora fine sandy loam occupies the higher topographical positions and shows minimal development of Grey - Black characteristics. The "A" or surface horizon is dark grey in color, 6 to 11 inches thick, finely granular in structure, very friable, moderately alkaline, and ranges in texture from sandy loam to very fine sandy loam. The "B" or illuvial horizon is generally absent, in which case the "A" horizon grades directly into a light grey lime carbonate accumulation horizon which in turn fades into a pale olive, moderately iron-stained, calcareous subsoil. A till or glacio-lacustrine substrate may be found at 2 to 6 or more feet from the surface.

The intermediately drained Zora sandy soils are similar in character to the better-drained type but are somewhat shallower in depth and more iron stained. In the shallow depressions degradation is in evidence. The poorly drained soils are usually covered by shallow peat. However much of the original peat has been removed by burning and in many sites only traces of the peat remain. The poorly drained Zora soils are calcareous, and a pronounced "G" or gley horizon is usually present. The "A" or surface horizon of the typical Meadow soil is 2 to 6 inches thick, mucky loam in texture, iron stained, and grades into a calcareous "G" or gley horizon, 4 to 12 inches in thickness, that blends into a sandy subsoil which is strongly iron stained.

The Zora loam to silty clay, is more poorly drained and has a thinner profile than its sandy loam counterpart. The intermediately drained soil associate is the representative soil. The typical soil has a dark grey "A" or surface horizon, 5 to 10 inches thick, that is finely granular in structure, friable, plastic, moderately calcareous, and iron stained; and it ranges in texture from loam to silty clay. This "A" horizon grades into an iron-stained lime carbonate accumulation horizon, 4 to 12 inches thick, which in turn fades into an iron-stained calcareous subsoil. A substrate of boulder till or glacio-lacustrine deposit occurs at variable depths. The poorly drained Meadow soils associated with the Zora loam to silty clay are similar to those associated with the Zora sandy loams. However, because of the finer texture and less porous condition that prevails, a longer period of time is required to aerate and oxidize these soils after the peaty overburden is burnt.

The Zora soil association as a whole is suited to mixed farming. The soils are fairly calcareous, but they will produce good crops of grain under good management practices. The soils are thin, and if plowed deeply, the materials from the "Ca" horizon may be brought to the surface. Grasses and legumes may be used to improve internal drainage on the heavier textured types, and to aid in the control of soil drifting which can be a serious problem especially on the sandy textured soils. Manure and combine straw should be returned to the land to supply organic matter. Where peat occurs in the poorly drained areas it should be incorporated with the mineral soil if possible, in place of destroying it by burning.

SEMPLE ASSOCIATION:

The Semple soil association consists of degrading Blackearth and associated soils, within the Grey - Black transitional zone, which have been developed on a thin mantle of fine lacustrine sediments, ranging from about 6 to 15 inches in depth, that rests on till or eroded till. The topography of the area is level to very gently sloping and slightly undulating. At the somewhat lower elevations where the underlying till has been covered with greater depths of lacustrine mantle, the Semple soils (under the influence of tree growth) grade into the Marquette soils (developed under grass). At the higher elevations the lacustrine mantle becomes thinner, tree growth becomes heavier, and degradation of the soils becomes more pronounced. Where the lacustrine mantle thins out and the till or reworked till is exposed, the Semple soils grade either into high-lime soils of the Garson association or into the Pelan soil association. Local areas of sandy loam and sandy clay loam soil similar to shallow phase Pelan soils, but too small in area to delineate in reconnaissance soil mapping, were included with the Semple soil association.

The dominant well to intermediately drained soil associate of the Semple association has a thin leaf and sod mat that is neutral in reaction. This organic layer rests on a very dark grey heavy clay loam to clay "A_1" horizon that is about 2 inches thick, well granulated, and neutral to slightly acid in reaction. The "A_1" horizon blends into a dark olive grey "A" leached horizon, 1 to 2½ inches in thickness, which is neutral to slightly acid in reaction and is composed of granular aggregates of hard consistence. The "B" or illuvial horizon is greyish brown in color, clay in texture, and is composed of organic coated small blocky structural aggregates. This horizon is 5 to 10 inches thick, quite dense and compact, and neutral to slightly alkaline in reaction. The "B" horizon grades sharply into a moderately calcareous "Ca" horizon of heavy clay loam to clay texture. Where the clay mantle is thin, the clay textured "C" horizon may be absent, and in such instances the "B" horizon rests directly on till. The lime carbonate accumulation horizon, which occurs immediately below the "B" horizon, may be developed in the lacustrine clay mantle or it may be found in the upper portion of the clay loam till. (See Figure No. 33)

Associated with the dominant Semple soil are intermediately drained, degrading Blackearth - Meadow soils and poorly drained Meadow soil associates. The intermediately drained degrading Blackearth - Meadow soils have profiles somewhat similar to their better-drained associates, but they are thinner, higher in lime, and the subsoils are somewhat mottled. The poorly drained or Meadow associates have either a mucky surface horizon or a superficial layer of peat up to 10 or more inches thick. The "A" horizon of the typical Meadow soil is thin and grades through a carbonate accumulation into either fine lacustrine sediments or boulder till. Meadow Podzols may occur in the slight depressional sections. These soils have a well-developed "A_2" or leached horizon, and a dense nutty structured illuvial "B" horizon. When cultivated the Meadow Podzols exhibit a light grey surface due to the color of the exposed "A_2" horizon.

The soils of the Semple association as a whole are best suited to mixed farming. They are moderately high in productivity but a considerable portion is still in the virgin state because of the combination of the cost of clearing the forest cover and a local stony condition of the soil. The arable soils are suitable to grain, grass, legume and root crop production. Nonarable areas may be utilized as woodlots or pastures. Poorly drained areas require provision for drainage and the removal of excess surface water. If adequately drained these poorly drained soils may be cultivated, but where drainage is inadequate, crop production is restricted to hay crops which are tolerant to some degree of flooding.

PELAN ASSOCIATION:

The Pelan soil association consists of Grey - Black and associated soils developed in the Grey - Black zone on a thin mantle of reworked sandy sediments over stony calcareous till. The landscape is characterized by smooth very gently sloping morainic topography with aspen-covered uplands and open meadows. Drainage is fair in the higher lands but large areas of poorly drained soils are common. The till substrate causes impeded internal drainage and wet subsoils are normal in wet years. A gravel or cobble lens is common at the junction of the till substrate and the sandy surface mantle. A large portion of the area is stony, especially where the overlying sandy mantle is thin. (See Figure No. 34.)

Two phases of the Pelan association were mapped on the basis of the depth of the sandy surface deposits, i.e.; the shallow phase and the deep phase. The shallow phase Pelan soil has a sandy mantle up to about 15 inches in thickness, and the deep phase Pelan soil has a similar textured mantle which ranges approximately 16 to 30 inches in thickness. However, the poorly drained associates which include Meadow, calcareous Meadow, and Peaty Meadow soils are common to both. The larger acreage of the poorly drained soils is found in the shallow phase areas.

(i) Pelan Soils, Shallow Phase:

The representative soil in the Pelan shallow phase is the well to intermediately drained (degrading Blackearth) associate. A dark brown leaf and sod mat overlies a dark grey sandy loam to fine sandy loam "A_1" horizon, 2 to 3 inches thick, that is very friable in consistence and neutral in reaction. This grades into a weakly developed dark greyish brown "A_2" horizon which is 2 to 3 inches thick, fine sandy loam in texture, structureless to weakly platy, very friable, and neutral to slightly alkaline in reaction. The "B" horizon is 3 to 4 inches thick, brown in color and usually slightly heavier in texture. Some granular or nutty structural aggregates with organic coating are commonly present in this horizon, however the degree of development is weak. The "B" horizon grades sharply into a 3 to 4 inch lime carbonate accumulation horizon which in turn fades into very pale brown till. A gravelly or cobbly lens is common above the till. The location of lime carbonate accumulation generally coincides with the location of the gravel or coarse textured lens. In much of the area occupied by this soil, stones are sufficiently frequent to interfere seriously with cultivation.

The soils associated with the dominant degrading Blackearth soils include well-drained, intermediately drained, and poorly drained associates. Large tracts of poorly drained soils occur. These soils may be Meadow, calcic Meadow, Peaty Meadow or Meadow Podzol soils. The most common type is a Peaty Meadow soil with an organic surface covering over a thin layer of sandy loam to sandy clay loam water-laid sediments. These soils are usually less sandy than the well to intermediately drained soils, and many stones protrude at the surface. Calcic Meadow, and Meadow Podzol types of poorly drained soils are also common. Degrading Blackearth or feebly developed Grey - Wooded soils occupy the local well-drained sites. Along the edges of the large tracts of Meadow soils or in slight depressional areas in the better-drained areas, narrow belts of intermediately drained Blackearth - Meadow soils occur.

Livestock farming is the main enterprise for which the Pelan shallow phase is suited. Coarse grain, flax, and other crops can be grown on the arable land but the area under cultivation is small. Wind erosion would be a hazard if a large area of this soil were exposed to the wind, however at present, large tracts of cultivated land seldom occur in this phase. Much of the Pelan shallow phase soil area is stony and nonarable. These areas are best utilized for pastures and woodlots. The Meadow and Peaty Meadow soils may be quite stony but they can be utilized for hay crops and pastures.

(ii) Pelan Soils, Deep Phase:

In the deep phase Pelan soils, the sandy mantle that lies over the till is approximately 16 to 30 inches in depth. The underlying till impedes internal drainage, thus the soils tend to have moist iron-stained subsoils and are dominantly intermediately drained. The representative intermediately drained soil is of the degrading Blackearth - Meadow type. It is characterized by a grey, neutral "A_1" horizon which is 1 to 3 inches thick, very friable, heavy fine sandy loam in texture, and rich in organic matter. The weakly developed "A_2" horizon is dark greyish brown in color, sandy loam in texture, and has weakly developed crumb structure. This horizon grades into 4 to 5 inches of weakly cemented light yellowish brown "B" horizon, which is loamy fine sand in texture and without definite structure. This horizon grades through a shallow transitional "B_3" horizon of olive yellow, iron-stained fine sand, into a lime carbonate horizon of pale yellow iron-stained fine sand. The "C_1" horizon is pale yellow calcareous sand that usually grades into the gravelly or cobbly lens commonly found at the contact with the underlying till strate. (See Figure No. 35.)

The poorly drained associates of the Pelan deep phase soils were to a large degree inaccessible at the time the soil survey was made, however, they include Meadow, calcic Meadow, Peaty Meadow and Meadow Podzol soils. In addition, small areas of degrading Blackearth soils occur on the crests of the slight elevations that protrude above the general level.

Stock raising is the most suitable form of land use on the Pelan deep phase soils. The cultivated land is low in fertility, somewhat poorly drained and more or less stony. On the arable land, coarse grains are grown mostly for livestock feed. Wind erosion is severe where large fields are exposed. Large areas of grazing and hay land occur in the poorly drained areas which provide hay and pasture for a livestock enterprise. Hence the arable land should be used to provide the required supplementary feeds. The installation of drains would do much to increase productivity because, in wet seasons, large areas of land are too wet even for hay and pasture use.

POPPLETON ASSOCIATION:

The Poppleton soil association consists of degrading Blackearth- Meadow and associated soils, in the Grey - Black transitional zone, developed under the influence of imperfect to poor drainage on well-sorted fine sand over till that occurs at depths exceeding 30 inches below the surface. The soils are generally intermediately to poorly drained due to the level topography and the impeded internal drainage caused by the till substrate. Nevertheless, local areas of degrading Blackearth (well to intermediately drained) soils occur in the higher sites where the sand deposits may be up to ten or more feet thick.(See Figure No. 36.)

The dominant soil associate is an intermediately drained Blackearth - Meadow soil. This soil has a thin mat of leaves and grass; an "A_1" horizon 2 to 6 inches thick, that is structureless, loose, loamy fine sand in texture, and neutral in reaction; and a loose, slightly acid "A_2" horizon which is light grey in color, 2 to 5 inches thick, and fine sand to sand in texture. The "B" horizon is pale brown to brown loamy sand, that is loose, structureless, neutral, iron stained, and 6 to 20 inches thick. Under the "B" horizon a light grey to pale yellow lime accumulation horizon occurs, which blends into a pale yellow, iron-stained, fine sand subsoil or "C_1" horizon. At depths of 30 inches or more from the surface, the sandy mantle is underlain by reworked calcareous till.

Soils associated with the dominant soil include well to intermediately drained and poorly drained associates. The well to intermediately drained soils have little profile character. In the "A" or surface horizon, below the "Ao" or leaf mat, there is little visible evidence of organic accumulation. At the base of the "B" horizon there is usually a thin layer of concretionary iron, underlain by a small accumulation of lime carbonate. The poorly drained soils are principally of the Peaty Meadow type although small areas of Meadow and Meadow Podzol soils occur. In some areas the Peaty Meadow soils are covered by conifers. Under the peat, the poorly drained soils have a very dark grey "A" or surface horizon, rich in organic matter, that ranges from a few inches to a foot or more in thickness. Below the "A" horizon, a bleached "G" or gley horizon is encountered which is often rich in lime and stained with iron. The gley horizon grades irregularly into a grey mottled and iron-stained subsoil.

The predominant intermediately drained Poppleton soils are most suited to livestock production. The soils are easily eroded by wind and no large continuous areas should be exposed to wind action. These soils are low in organic matter and fertility. However trees thrive, and natural forest or planted windbreaks should be maintained on the windward side of tilled fields. With manuring, (which includes addition of organic materials and the required fertilizers) fair yields of practically all the common crops can be grown, however crop rotations which feature grass and legume production are most suited to these soils. The better-drained Poppleton soils that are low in organic matter are suitable for forestry and to some extent for pasture use. As a rule the poorly drained soils are not cultivated, but are mainly used for hay and pastures or woodlots. However if adequate drainage can be provided some grain and tame hay crops could be grown on the poorly drained soils.

TOLSTOI ASSOCIATION:

The Tolstoi soil association consists of degrading Blackearth - Meadow soils and associates developed on 30 or more inches of a stony sandy mantle containing one or more lenses of gravel, which lies over a sandy modified till substrate. The surface deposits are more or less stony throughout, and a cobble lens usually occurs at the junction of the till and the sandy mantle. The Tolstoi soil association, which consists dominantly of intermediately and poorly drained soil types, covers less than 2,000 acres. It has a level topography marked by slightly elevated islands containing well to intermediately drained soils with degrading profiles. (See Figures No. 37.)

The dominant intermediately drained Tolstoi soils show little evidence of degradation. A typical soil profile shows a very dark grey "Ao" leaf and sod mat resting on a dark grey "A" or surface horizon, 8 to 10 inches thick, sandy loam in texture, structureless, and slightly alkaline in reaction. The "B" horizon is a light grey, structureless, alkaline fine sand, 4 to 6 inches thick, and usually containing a gravelly and cobbly lens in the lower portion of the horizon. The "C_1" horizon is pale yellow sand that is calcareous and iron stained. A till substrate underlies the sandy mantle at thirty or more inches. More than one lens of gravel or cobbles may be present in the outwash mantle on which the soil profile is developed and a cobble lens usually occurs at the junction of the sandy mantle and the till substrate.

Associated soils include a well to intermediately drained, degrading Blackearth, and poorly drained, Meadow, Peaty Meadow and Meadow Podzol soils. The well to intermediately drained associate has a light brownish grey "A_2" horizon, 3 to 8 inches thick, that is neutral in reaction. The "B" horizon is pale brown sandy loam, 6 to 10 inches thick, and slightly alkaline in the lower part of the horizon. Under the "B" horizon the sediments are stratified and, in common with the associated types, usually contain one or more lenses of gravel. The poorly drained associates are usually Peaty Meadow soils. These soils have a peaty surface cover resting on a thin horizon of mucky sandy loam 6 to 8 inches thick, which grades into a pale yellow calcareous iron-stained sand. In addition, a "G" or gley horizon is usually present and lenses of gravel are also common. In the Tolstoi soils, stoniness restricts cultivation. The land that is cultivated is used for coarse grain production to provide feed for livestock. The soils are low in fertility, and subject to wind erosion if any large tracts of land are unprotected from the wind. However, the cultivated area is limited due to stoniness and therefore even the better-drained soils of this association are used largely for the production of hay and pasture. The poorly drained soils also may be used either as pastures or hay land, but internal drainage in these soils is poor and surface drainage is essential if they are to be used satisfactorily for pastoral agriculture.

LEARY ASSOCIATION:

The Leary soils are shallow degrading Blackearths developed on stratified gravelly and sandy sediments. These coarse textured sediments were deposited as beaches in glacial Lake Agassiz, and as glacial outwash deposits in the form of kames, eskers, crevasse fillings and small coarse textured deltas. In the Grey - Black transition zone, the beaches are most prevalent at the lower elevations in the lake-terrace area. At the higher elevations the types of gravel deposits are not well defined and in some locations one form of gravel deposit may blend with that of another. (See Figure No. 38.)

The well-drained Leary soils have a weakly perceptible greyish brown "A_2" horizon of sand to coarse sand, and a fairly distinct "B" horizon which shows some illuviation but may not be heavier than loamy sand in texture. The "B" horizon grades into stratified coarse sand and gravel. In some soils the sandy surface is thin and gravel occurs immediately below the "A" or surface horizon. Some intermediately drained and poorly drained soils may occur along the edge of the beach ridges and also as islands in the gravel deposits which have an irregular topography.

The Leary soils are best adapted to grazing. However, because the soils are low in fertility and droughty in nature, they have a low carrying capacity. A few grain crops such as rye have been grown on newly broken areas, but the soils may be considered submarginal for grain crops. The gravel from these deposits can be utilized for road construction and building materials.

SOILS OF THE GREY WOODED ZONE:-

Grey Wooded soils in the eastern portion of the Winnipeg-Morris map areas have been developed under Boreal forest vegetation and, in virgin condition, are characterized by a mat of forest litter and organic residue (or "Ao"), by a grey, ash-like "A_2" eluvial horizon, that is granular to platy in structure, and slightly acid (or neutral) in reaction; and by a brown to greyish brown more or less nutty structured "B" or illuvial horizon that grades into a well-defined accumulation of lime carbonate. Between the leaf mat and the "A_2" horizon, a thin grey black crumbly "A_1" horizon may be present, in which the organic matter from the "Ao" has been mixed with the upper portion of the mineral soil by organisms. In some cases the grey black crumbly "A1" horizon is absent.

The climate of the Grey Wooded soil zone is cooler and more moist than the Blackearth zone. The higher precipitation-effectivity favors tree growth, and the tree cover together with the more moist soil climate favors degradation or leaching in the upper part of the soil profiles. In the Grey Wooded zone of the Winnipeg-Morris map areas, wooded uplands with either grassy or wooded swamps in the associated hydromorphic sites are characteristic features. Mixed stands of aspen and oak are most common, but areas of mixed woods occur in which white spruce is intermixed with oak, aspen and balsam poplar. In local areas, where the soil climate is dry, due to coarse texture and droughty soil conditions, jack pine and big bluestem are characteristic. Because the topography in this area of Grey Wooded soils is generally irregular, large areas of the poorly drained soils occur. Wet-land grasses and sedges which form and grow over fen peat are common on the poorly drained sites in the southern section, but black spruce and tamarack, along with swamp birch, willow and associated hydrophytic plants are commonly found on the peat deposits and wet sites in the northern section.

The soils in the Grey Wooded zone of the Winnipeg-Morris map areas include the Saltel, Brokenhead, Caliento, Pine Ridge, Vita, and Birds Hill associations, and the Garson soil complex.

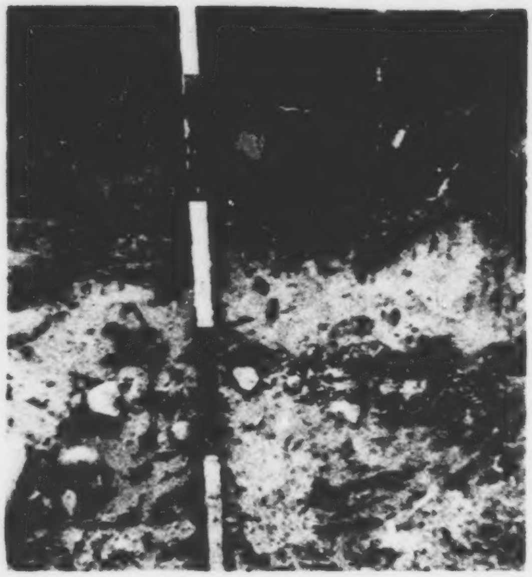

Figure No. 35
Soil profile of Pelan deep phase. A degrading Blackearth - Meadow Intergrade developed on a sandy loam mantle that is separated from the underlying till by a gravel or cobble lens.
(Measuring stick interval = 6 inches.)

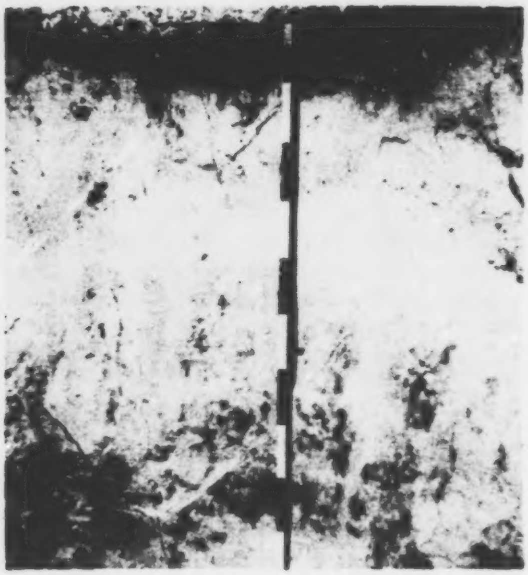

Figure No. 36
Soil profile of Poppleton fine sand. A degrading Blackearth - Meadow Intergrade developed under imperfect to poor drainage on well-sorted fine sand with till substrate.
(Measuring stick interval = 3 inches.)

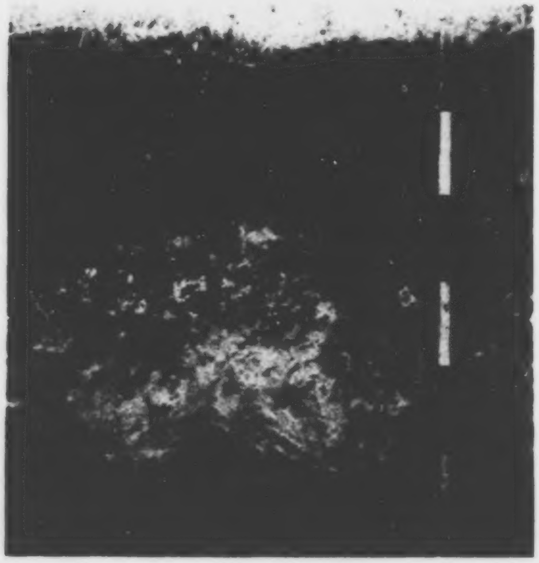

Figure No. 37
Soil profile of Tolstoi sandy loam. A degrading Blackearth - Meadow Intergrade developed on a stony sandy mantle that contains one or more lenses of gravel.
(Measuring stick interval = 6 inches.)

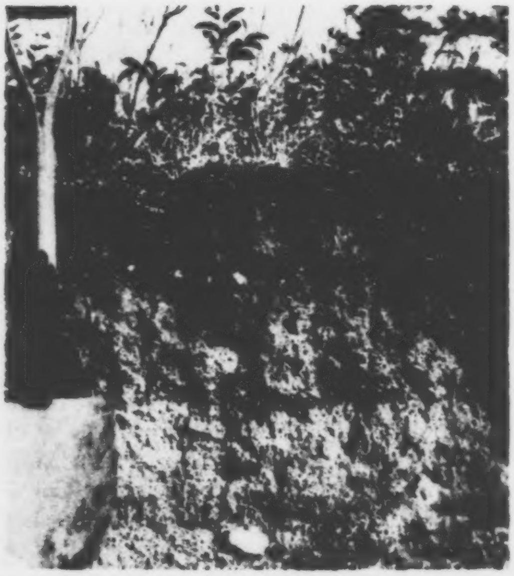

Figure No. 38
Soil profile of Leary sand over gravel. Shallow degrading Blackearth developed on sandy and gravelly deposits.

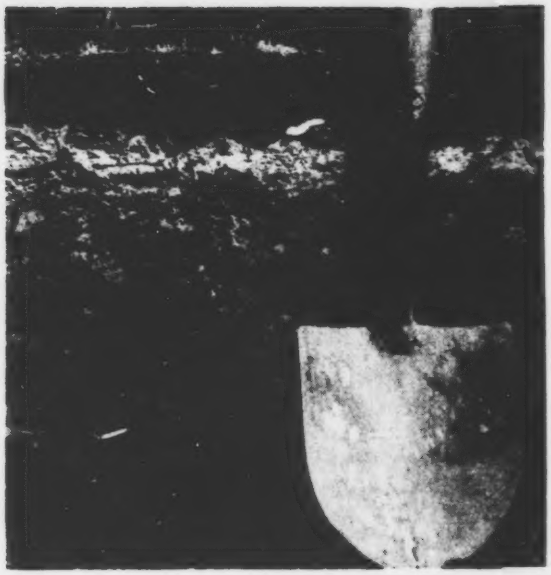

Figure No. 39
Soil profile of Brokenhead clay. Grey Wooded soil developed on fine textured sediments.

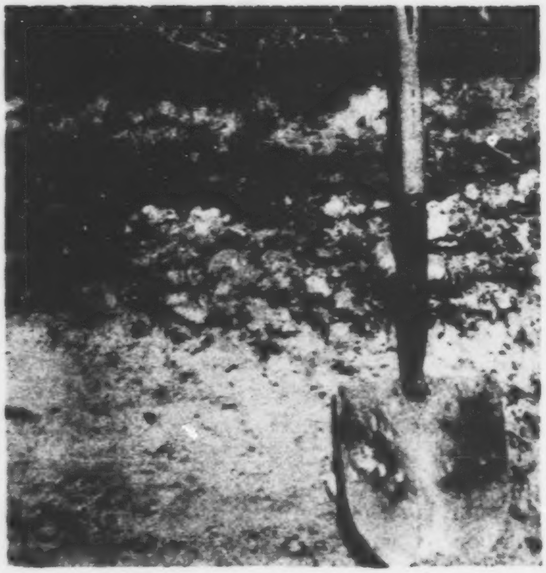

Figure No. 40
Representative soil profile, Garson complex. Degrading Rendzina or calcic Grey Wooded soil developed on thin sandy mantle over stony reworked calcareous till.

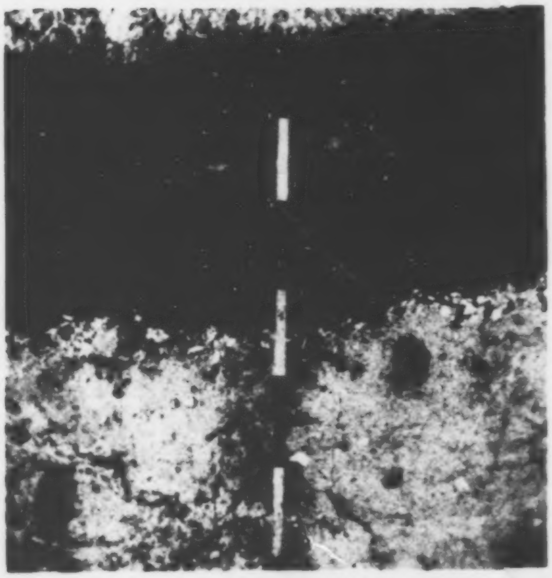

Figure No. 41
Soil profile of Caliento fine sand. A humid Grey Wooded soil developed on sandy mantle over water-modified calcareous till. (Measuring stick interval = 6 inches.)

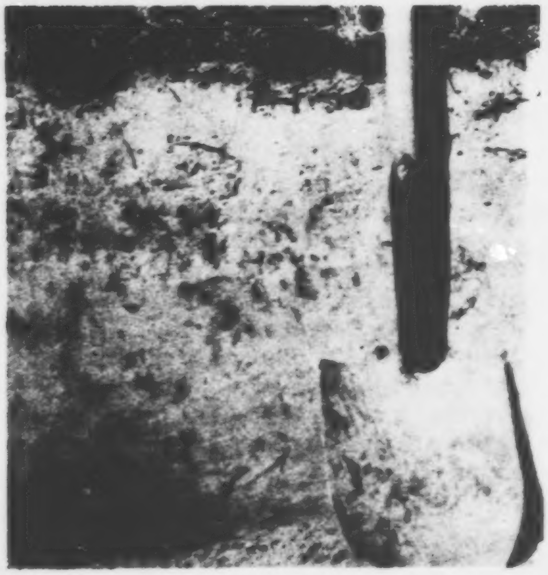

Figure No. 42
Soil profile of Pine Ridge fine sand. Grey Wooded soil developed on sand.

SALTEL ASSOCIATION:

The Saltel soil association consists of soils within the Grey Wooded zone, which have developed under Boreal forest on a thin mantle of clay textured lacustrine sediments, up to 15 inches in depth, over calcareous till, and under the influence of imperfect drainage. This association of soils occupies flat depressional areas which were covered by glacial Lake Agassiz for a sufficient period of time to permit the deposition of the clay sediments. However, where the clay mantle is thin, some stones may be in evidence. Mixed woods of aspen, oak, willow and spruce have influenced soil development on the better-drained sites, and black spruce and tamarack, as well as reeds and sedges, are the dominant vegetation of the poorly drained sites. Soil profile development in the Saltel soils has been slow because of clay texture and imperfect drainage.

The dominant soil is the intermediately drained or "humid Grey Wooded" associate. In the virgin condition, this soil has a leaf mat about two inches thick which rests on a grey "A_2" horizon, 1 to 2 inches thick, that is heavy clay loam to clay in texture, granular to platy in structure, and slightly acid in reaction. This horizon grades sharply into a blocky, dark brown clay "B" or illuvial horizon which is about 5 inches thick, and neutral in reaction. The "B" horizon in turn grades sharply into a lime carbonate accumulation which is heavy clay loam to clay in texture. The lime carbonate accumulation blends into a gravelly or cobbly lens that lies between the clay mantle and the calcareous till. The till below the gravelly lens is pale brown in color, slightly modified by water and has a fragmental structure.

The soils that occur in association with the dominant soil include Peaty Meadow and Meadow Podzol soils. The peaty surface deposits, which are shallow in the Peaty Meadow soils, may increase in thickness and grade into organic deposits which may be up to four feet thick, thus passing from Peaty Meadow through Half-Bog to Bog type of soils. The peat found in the Saltel soil area is usually acid in reaction but the underlying clay, which may be two or more feet in depth, is calcareous. The clay sediments lie over a highly calcareous boulder till.

The Saltel better-drained soils are suited to a mixed farming type of land use in which crop rotations that feature the growing of grasses and legumes are essential. Areas on which the clay mantle is very thin, so that stones interfere with cultivation, can be used as pasture land or woodlots. The poorly drained Meadow soil areas may be used for the production of wild hay and pasture in the drier years, however, in wet years ponding of water on the poorly drained sites may be extensive. Where feasible, reclamation of the peat areas by drainage is desirable; but burning the peat to remove the organic overburden is not advisable, without detailed examination of the underlying material, because stoniness may severely restrict subsequent cultivation. Moreover, a clean "burn" results in the deposition of ashes on mineral materials that are low in organic matter. Such materials must be improved by manure or grasses and legumes as well as by drainage, before they can be reclaimed for arable culture.

BROKENHEAD ASSOCIATION:

The Brokenhead soil association consists of Grey Wooded and associated soils which have developed on approximately 16 to 30 inches of fine textured lacustrine sediments which lie over calcareous lake-washed till. This association occupies a low-lying, level area which is a portion of the Lake Agassiz clay plain. Subsequent to the recession of the glacial lake, this level area has been modified by deposition from streams and runways meandering through it. The Brokenhead soils consist of an area of about 3,000 acres in a portion of the region drained by the Brokenhead River and Hazel Creek. Soil profile development here has been influenced by imperfect drainage caused by the clay texture and level topography.

The well to intermediately drained Grey Wooded soil associates have a dark greyish brown, slightly acid leaf mat, 1 to 2 inches thick, that grades through a shallow very dark grey clay "A_1" horizon into a greyish brown sandy clay loam "A_2" horizon, 2 to 4 inches thick, that is feebly platy in structure, friable and slightly acid. The "B" or illuvial horizon is a dense dark brownish grey clay, 17 to 22 inches deep, with distinct nutty to finely blocky structure, that is neutral in the upper portion and slightly alkaline in the lower part of the "B" horizon. This horizon grades sharply into a lime carbonate accumulation which in turn blends with an olive grey "C_1" horizon. In some sites the carbonate horizon serves as a transition to the calcareous till substratum. (See Figure No. 39.)

Soils associated with the Grey Wooded member include intermediately drained or humid Grey Wooded soils, Peaty Meadow, Meadow Podzol soils, and local areas of Grey - Black soils. The intermediately drained soils are generally leached to some degree although, in some locations, the "A_2" horizon may not be perceptible and such soils resemble the Grey - Blacks. The thin peaty mantle of the Peaty Meadow soils may be continuous with organic deposits which may be up to 4 feet in thickness, thus passing from Peaty Meadow through Half-Bog and Bog soils. Small areas of Meadow Podzol soils occur in depressional locations. Since settlement, the area covered by a peaty mantle has been reduced considerably by improved drainage and subsequent destruction of the peat by fire.

Good yields of cereal crops, grasses and legumes are produced on the better-drained Brokenhead soils, which are good soils for general farming. However, owing to the imperfect natural drainage, surface drains are essential. Moreover, there may be some local flooding from river waters in years of excessive moisture. Manure and grass legume crops are needed to maintain organic matter and to improve the tilth and workability of these soils. In the reclamation of the associated Peaty Meadow soils, a portion of the peat should be mixed with the clay mineral soil to improve its fertility and physical properties.

GARSON SOIL COMPLEX:

The Garson soil complex is a group of soils within the Grey Wooded zone which contains degrading Rendzina soils, developed on reworked calcareous boulder till, and minimal Grey Wooded soils developed on a mantle of sandy and stony erosional residue, up to 15 inches in depth, resting on reworked calcareous boulder till. All degrees of transition between these two soil types occur but soils with a very thin sandy mantle predominate, and intrazonal soils, common to the Grey Wooded zone, are found in association. The Garson soils are all more or less stony, and in many cases have a cobbly or gravelly lens under the thin sandy mantle. The irregular very gently sloping topography has many depressions in which poorly drained soils occur. These local depressional areas are especially common where these soils occur in the Morris map sheet area.

Considerable variation in soil profile characteristics are found in the soils of the Garson complex. The well-drained soils which are developed directly on the boulder till are very shallow degrading Rendzina soils. They have a thin leaf mat which grades through a shallow "A_1" into a shallow sharply delineated sandy clay loam "A_2" horizon, 1 to 4 inches thick. This "A_2" horizon is neutral in reaction and grades sharply into a brown clay loam, nutty structured "B" or illuvial horizon, 2 to 5 inches thick, which in turn grades into calcareous boulder till. The better-drained soils that have a sandy mantle over the calcareous till have deeper profile development. The "Ao" or leaf mat, and the "A_1" horizon are similar to those described above, but the "A_2" horizon may be up to 6 inches thick, slightly acid in reaction, and sandy loam in texture, The "B" or illuvial horizon is 6 to 8 inches thick, sandy loam to sandy clay loam in texture, nuciform or nutty in structure, and neutral to slightly acid in reaction. This horizon usually grades through a transitional horizon into a lime carbonate accumulation which overlies, or may be developed in, light grey calcareous boulder till. All variations between the soils represented by these profile descriptions are found. A gravel or cobble lens is commonly found at the contact of the sandy mantle and the underlying boulder till. In areas where the gravel lens occurs near the surface, the gravel lens (which is dominantly calcareous) apparently limits the depth of profile development. (See Figure No. 40.)

Soils associated with the somewhat better-drained Garson soils include intermediately drained and poorly drained types. In the intermediately drained soils the grey "A_2" horizon is feebly expressed and, in some cases it is difficult to distinguish. However in these locations a slight brown colored "B" horizon has been formed through illuviation. The poorly drained soils are usually of the Peaty Meadow type, but local areas of Meadow Podzol soils occur. The Peaty Meadow soils often grade into Half-Bog and Bog soils which are underlain by geological deposits similar to those on which the Garson soils have developed.

The agricultural possibilities and land-use practices of the Garson soils are quite variable. Small areas can be cultivated but most of the area occupied by these soils is nonarable because of excessive stoniness. The less stony arable soils are fair for grain, and fair to good for grasses and legumes. Yields can be increased markedly by the application of phosphate fertilizers. Some excellent yields of alfalfa seed have been obtained on small clearings where adjacent woods provide a natural habitant for pollinating insects. The stony land, and the land which has a relatively thick gravel lens near the surface are nonarable. They may be used for woodlots and pastures. The poorly drained areas are usually excessively stony and nonarable. In the management of the associated peat and Peaty Meadow soils, care should be taken to avoid burning the peat because such areas, if not burned over, can be pastured or used for hay. Hay and pastures produced on these soils are generally low in phosphate, so that animals, fed on such feeds, exhibit phosphorus deficiency. Hence the use of phosphate fertilizers applied to the soil or the addition of a mineral supplement, containing phosphorus, to the cattle ration is essential.

CALIENTO ASSOCIATION:

The Caliento soil association consists of humid Grey Wooded and associated soils, in the Grey Wooded zone, that have been developed on sandy deposits, approximately 16 to 30 inches thick, over water-modified calcareous boulder till. Stones or large boulders protrude into and through the sandy mantle. The soils are dominantly imperfectly drained because the smooth very gently sloping topography has little relief, and because internal drainage is impeded by the till substrate. A large portion of the area involved is poorly drained due in part to the numerous large, shallow, undrained depressions that occur within the boundaries of this association.

The intermediately drained or humid Grey Wooded soil is the dominant associate occurring in this association. This associate may be recognized by a neutral dark grey leaf mat over a dark grey fine sandy loam "A_1" horizon, which is 2 to 3 inches thick, extremely friable and neutral in reaction. The "A_2" horizon is light grey fine sand, 3 to 6 inches thick, which is loose and structureless, and neutral to slightly acid in reaction. The "B" horizon is olive yellow loamy sand to fine sand, 6 to 10 inches thick, weakly cemented, neutral, and may be iron stained. This horizon grades into a pale yellow lime accumulation horizon which is underlain by pale brown calcareous till. A cobble or gravel lens may occur at the junction of the till and the sandy mantle. (See Figure No. 41.)

The soils that occur as associates of the dominant intermediately drained member include well-drained and poorly drained soils, and soils which show minimal expression of Grey Wooded character. The well-drained soils are found only in small slightly elevated areas. These soils are strongly leached and are low in organic matter. The "A_2" horizon is 6 to 12 inches thick, loose and moderately acid. It blends into a pale brown "B" horizon, about 12 inches thick, that is slightly acid in reaction and weakly cemented with iron compounds. The poorly drained soils are dominantly of the Peaty Meadow type and usually grade into Half-Bog and Bog soils. In the southern part of the map area, the organic deposits are mainly fen peat, whereas in the northern section a considerable proportion of woody residue occurs in the peat. The Half-Bog and Bog soils that are shown in the soil map as lying adjacent to the Caliento association, are underlain by mineral deposits similar to the parent materials on which the Caliento association has been developed. Local areas of Meadow Podzol soils occur in the small micro-depressions where internal drainage is not arrested.

The Caliento soils are best suited to livestock production. Much of this association is nonarable due to stoniness and drainage difficulties. The natural land use for such areas is woodlots and pastures. The natural fertility of the soils is low and the sandy textured surface mantle is very susceptible to wind erosion. This soil association occurs in an area which has a favorable climate for hay and pasture production. On arable land, soil improvement crops should be used in rotation with coarse grain crops to provide feed for livestock, and the manure and the necessary fertilizers should be used to increase soil fertility. The poorly drained or Peaty Meadow soils are restricted in land use to the production of wild hay and pasture in dry years; in wet years these soils may be more or less covered by water for much of the growing season. In general the native hay is coarse, poor in quality and low in food value.

PINE RIDGE ASSOCIATION:

The Pine Ridge soil association consists of sandy textured Grey Wooded and associated soils, which have developed on sandy deposits, over 30 inches in depth, underlain by calcareous till or stratified gravelly sediments. In some areas low dunes are in evidence. In the Pine Ridge district where the topography is somewhat irregular, the soils are largely well drained because the sandy deposits are relatively deep and have good to excessive drainage. However, in other districts where the topography is smoother and the sandy deposits are thinner, the soil profiles are more or less influenced by a fluctuating water table which may occur above the till substrate. The native vegetation on the well-drained sites varies to some degree from the vegetation normally associated with Grey Wooded soils. Stands of jack pine, poplar, scrub oak, and scattered spruce are interspersed with small open areas of prairie. The well-drained soils in this association usually have Grey Wooded soil characteristics, but degrading Blackearth soils are common in the local grassland areas.

The representative well-drained associate is a Grey Wooded soil in which the leaf mat grades through a thin "A_1" horizon into a grey "A_2" horizon, 5 to 8 inches thick, fine sand in texture, and slightly acid to neutral in reaction. This horizon grades gradually into a light brownish grey "B" or illuvial horizon that is loamy fine sand to fine sandy loam in texture, 7 to 20 inches thick, extremely friable to loose, structureless, and neutral to slightly alkaline in reaction. The "B" horizon blends with a light grey, sandy, carbonate horizon, 5 to 8 inches thick, that is cemented when dry, and sometimes gravelly or cobbly. This "Ca" or lime carbonate horizon blends into a "C_1" horizon that consists of pale yellow calcareous fine sand. At 30 or more inches from the surface, a pale yellow to pale brown calcareous till or coarse textured drift may be encountered. (See Figure No. 42.)

The soils that are associated with the representative associate include humid Grey Wooded, Peaty Meadow, Meadow Podzol and degrading Blackearth soils. The intermediately drained soil associate is a humid Grey Wooded soil that has a similar profile to that described above, but it usually is shallower in depth, iron stained in the lower portion of the profile, and has a moist subsoil. The poorly drained soil associates encountered, are usually Peaty Meadow soils which are covered by variable depths of a peaty mantle which may grade into Half-Bog and Bog soils. An iron-stained gley horizon usually occurs in the mineral portion of these poorly drained soils. Local areas of Meadow Podzol soils occur but the area covered by these types is insignificant. Degrading Blackearth soils are encountered as associates in the well-drained, grass-covered sites, especially in the area northeast of Winnipeg commonly referred to as the Birds Hill area.

The Pine Ridge soils are restricted in land-use possibilities. The well-drained soils are poor for grain production because of low water retention capacity and low organic matter content. In the more favorable sites some coarse grains may be grown in rotation with grasses and legumes, but it is advisable to grow the soil-improvement crops 3 or 4 years out of 5 to reduce the susceptibility of the soil to wind erosion and to improve the fertility status. The intermediately drained soils with moist subsoils are more fertile, because they are somewhat higher in organic matter, less subject to intense leaching, and are less droughty. However these sandy soils cannot support a sustained system of grain cropping for any length of time. Grain growing should be subordinate to grassland farming. Grain crops should be restricted to the supplementary concentrates required by the forage consuming animals. The poorly drained peaty soils will produce fair crops of hay if the water level is controlled. It is extremely important to avoid burning the peat on these soils because of the low fertility and low water retention capacity of the underlying sand.

VITA ASSOCIATION:

The Vita soil association consists of humid Grey Wooded, Grey Wooded and associated soils that have developed on a stony, sandy mantle over 30 inches in depth which contains one or more gravel lenses and lies over a till substrate. The topography is level to very gently sloping and is marked by depressional areas which are usually wet. The soils of this association are limited in extent and are localized in the vicinity of the town of Vita in the southeast corner of the Morris map sheet area.

The dominant associate in the Vita association is well to intermediately drained and may be classed as of the humid Grey Wooded type. The representative profile has a thin leaf mat that grades through a thin dark grey "A_1" horizon into a pale brown fine sand "A_2" or leached horizon, which is 3 to 7 inches thick, structureless and neutral to slightly acid in reaction. The "B" or illuvial horizon is 5 to 8 inches thick, brown in color, weakly granular to structureless, and neutral to slightly acid in reaction. Frequently, a lens of cobbles or gravel may be present either in the "B" horizon or at its base. The lime carbonate horizon that normally occurs below the "B" horizon is not distinct but blends with the calcareous sand subsoil. At a depth of 30 or more inches the sandy mantle is underlain by a calcareous light grey to pale brown till. (See Figure No. 43.).

The soils associated with the dominant associate include somewhat better-drained, intermediately drained, and poorly drained types. The better-drained soils which occur on the somewhat higher lying sites are degrading Blackearth or Grey - Black associates. The intermediately drained soil associate is similar to the well to intermediately drained associate, but the "A_2" and "B" horizons are not so well expressed, and the reaction of these horizons is invariably less acid; moreover, mottling by iron and lime carbonate in the lower portion of the soil profile is more strongly pronounced. The poorly drained soil associates are mainly Peaty Meadow soils which grade into Half-Bog and Bog soils. Under the peat, the mineral materials are usually slightly finer in texture than the soils of surrounding better-drained areas, and a gley horizon is common.

The soils of the Vita association can be utilized most favorably for livestock production. Stoniness is a serious problem, and a large portion of the area is nonarable in which case the land may be used as pastures or woodlots. Some coarse grains can be grown on the less stony arable lands, to provide grain for livestock. However the natural fertility of these soils is low and the land is more suited to growing grasses and legumes. Grain crops should only be grown in rotation with soil-improvement crops, and manure and fertilizer is required to increase crop yields. Because of wet conditions, the Peaty Meadow soils are limited in use to wild hay and grazing in drier seasons. Controlled drainage would improve these soils and make them more suitable for hay production.

BIRDS HILL ASSOCIATION:

The Birds Hill soil association consists of coarse textured Grey Wooded and associated soils that have developed on coarse sandy and gravelly outwash deposits in the form of kames, osars, and beaches. Many surface boulders may occur especially in the Birds Hill area. The topography varies from variable sized ridges to irregular gently sloping hillocks. A gradation in profile character of the well-drained soils from blackearth-like to Grey Wooded soils can be found. The cobbly knolls which are usually under grassland vegetation have blackearth-like characteristics, whereas the coarse sandy and fine gravelly soils under forest show distinct Grey Wooded characteristics. Where a large percentage of coarse gravel and cobbles prevail, the horizons have less thickness, and the soil characteristics are weakly expressed. The Birds Hill soils which occur in the easterly locations are more strongly leached than the soils occurring in the vicinity of Birds Hill.

The depth of soil profile seldom exceeds 12 inches in the representative well-drained Birds Hill soil. The dark colored "A_1" horizon may be absent or up to 3 inches thick. The "A_2" horizon is a light brownish grey sand, 2 to 4 inches thick, and slightly alkaline due to the presence of numerous small partially decomposed limestones. The "B" or illuvial horizon is brown to yellowish brown, light sandy loam in texture, 3 to 5 inches thick, and moderately alkaline in reaction. This horizon may contain some clay although the amount is usually less than ten percent The "C" horizon consists of pale brown to light yellowish brown stratified sand and gravel. (See Figure No. 44.)

The soils associated with the representative well-drained associate include humid Grey Wooded, Peaty Meadow, degrading Blackearth and small areas of Blackearth soils. The intermediately drained or humid Grey Wooded associates have similar soil profiles to the well-drained soils but are mottled in the lower portions of the soil profile. Peaty Meadow soils occur as associates in the poorly drained positions and grade into Half-Bog and Bog soils. Degrading Blackearth and blackearth-like soils occur on the cobbly grass-covered knolls, where profile development has been restricted.

In general, the typical Birds Hill soils are of very poor agricultural value. They may be utilized for grazing but they have a very limited carrying capacity. Some areas have been utilized for growing a few rye crops, but the soils are low in fertility, droughty, and when exposed, are susceptible to wind erosion. However, the gravel deposits on which this soil association has developed are an important source of gravel for road construction and building purposes.

LOCAL SOIL AREAS:-

Several local or azonal soil areas are shown on the Winnipeg-Morris map sheets in which soils are found that do not have the zonal soil characteristics common to the zone in which they occur. The characteristics of these local soils are influenced profoundly by parent material, immaturity, or drainage. The local soil areas here referred to include the Menisino soils, (deeply leached podzolic soils developed on jack pine sand); the Isafold soils, (shallow highly calcareous Rendzina soils); the Oakville and Riverdale soils (juvenile soils developing on alluvial materials more or less subject to periodic inundation); recent Alluvium; and Organic or Half-Bog and Bog soils.

MENISINO ASSOCIATION:

The soils of the Menisino association consist of sandy podzolic soils which have developed under jack pine, and sparse growths of gound juniper, indigeneous grasses and herbs. The Menisino soils occur as local areas within the Grey Wooded soil zone, and are found on the Morris map sheet in the vicinity of Marchand and Zhoda. Boulders are encountered in the Menisino soils; some areas may be very stony and other areas reasonably stone free. The sandy deposits are relatively thick and appear to have been reworked by ice and duned to a minor extent after recession of the ice. The well-drained soils which occur at the crests of ridges show very little profile character, but the intermediately drained soils in the lower positions have morphological character somewhat similar to the Pine Ridge soils that have similar drainage. Differentiation between the Menisino and Pine Ridge types is based on stronger acidity and lower quantities of lime carbonate in the Menisino soils.

The well-drained soil is the dominant and typical member of the Menisino association. This soil has little character and its horizons are distinguishable only by faint changes in color and reaction. A thin "A_1" horizon, $\frac{1}{2}$ to $1\frac{1}{2}$ inches deep, which is made up of light grey to light brownish grey, structureless, slightly acid, loamy sand to fine sand, grades into an "A_2" horizon of light grey sand or fine sand, 4 to 6 inches or more thick, that is structureless, loose, and acid in reaction. Below the "A" horizon there is an indefinite "B" or illuvial horizon of variable depth, consisting of very pale brown sand or fine sand, which is structureless, loose, and acid in reaction, and grades into structureless pale yellow sand to fine sand that is neutral in reaction. A slight accumulation of lime, as indicated by a slightly alkaline soil reaction, may occur within the "C" horizon. (See Figure No. 45.)

The intermediately drained Menisino soil associate has distinct horizons that are less acid and shallower in depth than in the well-drained soil associate. The profile is marked by the accumulation of iron compounds in the "B" horizon, and an iron-stained subsoil which contains a distinct lime accumulation. The Menisino poorly drained soil associates are peaty types. All the peat deposits have an acid reaction. However because hydromorphism is the dominant factor, the resulting soils on the Menisino sand have characteristics that are common to, and may be considered as correlated with, the hydromorphic soils of the Pine Ridge association.

The Menisino soils in general are suited principally to forestry and unsuited to agriculture. They provide a fairly good growth site for jack pine, red pine and white spruce. Blueberries grow well on these acid soils, and in favorable sites a fairly good grade of tobacco can be produced* if suitable provisions are made for fertility and moisture supply.

ISAFOLD ASSOCIATION:

The Isafold soil association consists of shallow highly calcareous soils which has developed under the influence of grasses and scrubby aspen on lake-washed limestone boulder till. These soils have thin dark colored surface horizons containing limestone or dolomite fragments. The high lime content of the soil parent material has been a dominant factor in their development, and hence they are classed as

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* The suitability of these soils for the production of Burley and cigarette tobacco has been demonstrated by C.S. Prodan, Prov. Dept. of Agric., Winnipeg.

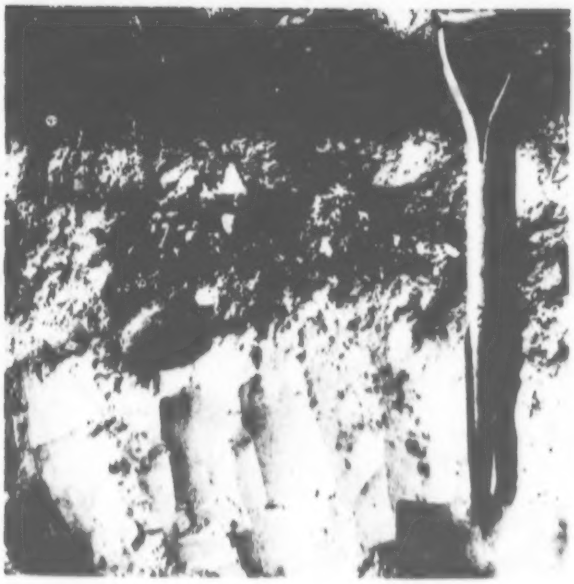

Figure No. 43
Soil profile of Vita fine sand. A humid Grey Wooded soil developed on stony, sandy deposits containing lenses of gravel.

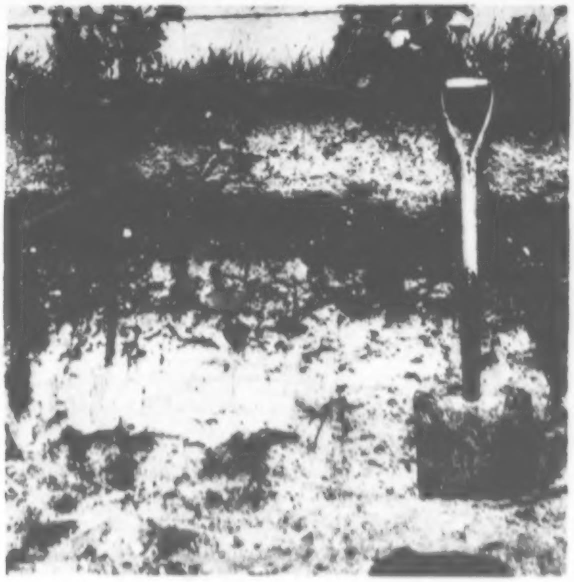

Figure No. 44
Soil profile of Birds Hill sand. A Grey Wooded soil developed on coarse textured sandy and gravelly outwash deposits.

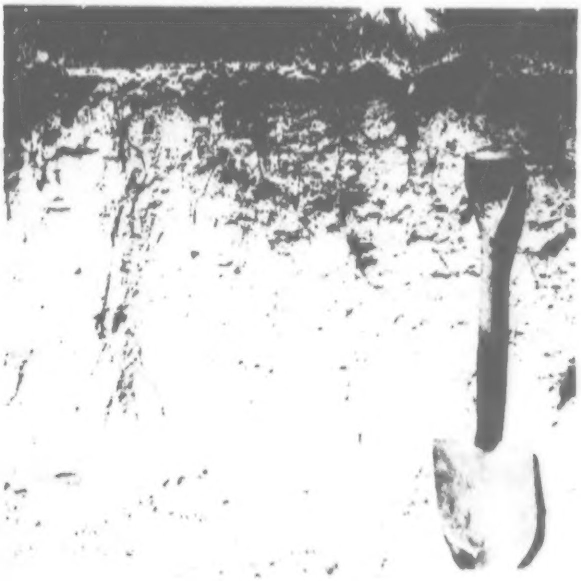

Figure No. 45
Soil profile of Menisino sand. Sandy podzolic soil developed under jack pine.

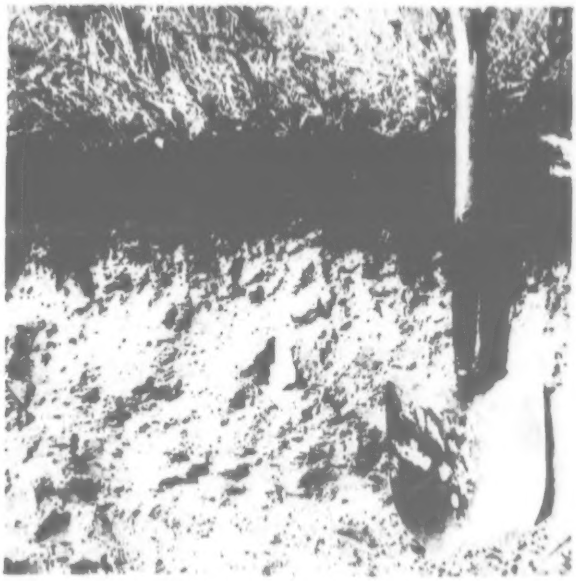

Figure No. 46
Soil profile of Isafold gritty loam. A Rendzina or shallow, dark colored, high-lime soil developed on lake-washed till derived from limestone.

Rendzina or high-lime soils. Isafold soils are frequently very stony and contain a gravel or cobble lens at shallow depths which often marks the depth of profile development. The terrain is slightly undulating and is marked by intermittent swales and ridges. The swales are often covered by a thin covering of lake-washed sediments, while the ridges are usually stony and cobbly.

The representative Isafold soils are well to intermediately drained. The "A" or surface horizon is dark grey fine sandy loam to clay loam, ranging from 4 to 8 inches in thickness, that is finely granular friable, and contains a considerable amount of lime carbonate. The dark surface horizon grades through a thin transitional horizon, that is dark greyish brown in color, granular, friable and alkaline in reaction, into a sharply defined marly lime carbonate accumulation. A gravelly or stony lens is common at or just below plow depth. The parent material has been derived largely from limestone and dolomitic rocks of the Interlake region. The color of the till varies according to the ancestral rock from which it was derived. Grey and pale yellow to light khaki colors are most common, but in many sites, the mixing of red shale and limestone as rock flour and rock fragments by glacial action has resulted in the pink, yellow, and grey mottled subsoils that are sometimes observed. (See Figure No. 46.)

The associated soils include intermediately drained, poorly drained and very slightly degrading associates. The intermediately drained soils have a thin dark colored "A" horizon which also contains a high content of lime carbonate. These soils are slightly thinner than the better-drained type. The poorly drained soils are usually calcic Meadow soils, together with areas of salinized Meadow and Peaty Meadow soils. These poorly drained soils occupy the depressional sites and trough-like swales. In the poorly drained soils, a thin covering of water-deposited sediments may occur over the calcareous boulder till. Normally tree vegetation does not thrive in these Rendzina or high-lime soils owing to their high lime content and alkalinity. Although invasion by poplar has taken place, the trees are generally scrubby, unthrifty, prematurely decrepid and short-lived. However in local areas, with succeeding generations of aspen and associated shrubs, some modification or leaching of the lime from the surface soil has taken place, and this is reflected in a somewhat more greyish "A" horizon. In time, and with persistent forest cover, these local soil associates may develop into degraded Rendzina types. At the present time, however, the Isafold soils with a thin light grey "A_2" horizon may be considered as degrading associates.

Because of extreme stoniness and low natural fertility, very little of the Isafold soil association that occurs in the Winnipeg map sheet area is under cultivation. Moreover, the high lime content of the soil has an adverse affect on soil fertility. The latter may be offset largely by using barnyard manure or ammonium phosphate fertilizers so that fair crops of coarse grain and flax may be produced. Alfalfa seed has been grown successfully on the better Isafold soils. The poorly drained associated soils can be utilized for hay and pasture, but native hay and forage is invariably poor in quality. The native hay meadow could be improved by sowing more suitable grasses and by the addition of phosphate fertilizers. Phosphorus deficiency is common in cattle in this area, unless they are provided with a phosphorus supplement or unless phosphate fertilizers are applied in adequate quantities to the soil on which the feeds are produced.

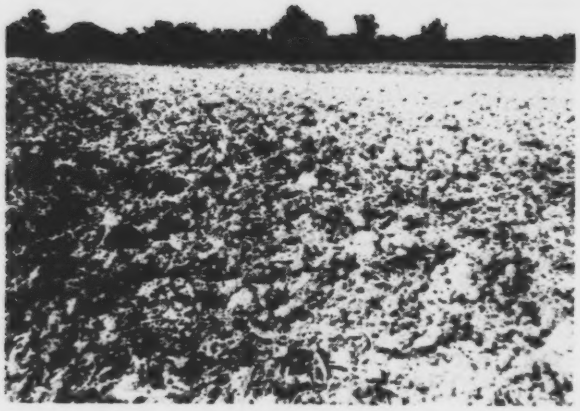

Figure No. 47
A field on Riverdale silty clay loam. A highly fertile juvenile soil under deciduous forest on river terrace and flood plain.

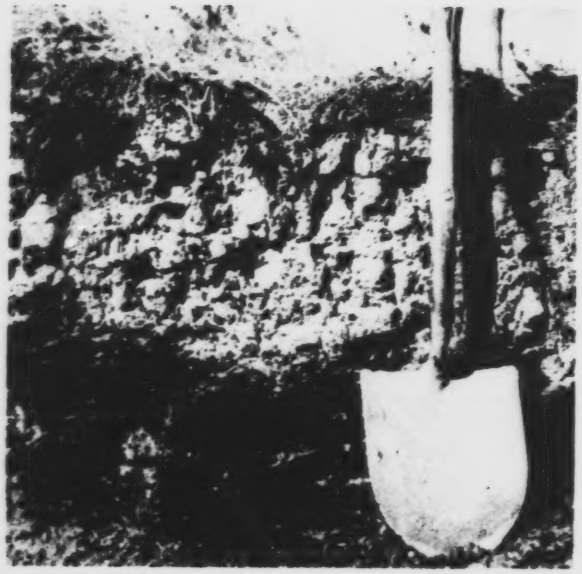

Figure No. 48
Soil profile of Oakville silty clay loam. An immature soil with feebly expressed horizons on alluvial sediments deposited on a river flood plain.

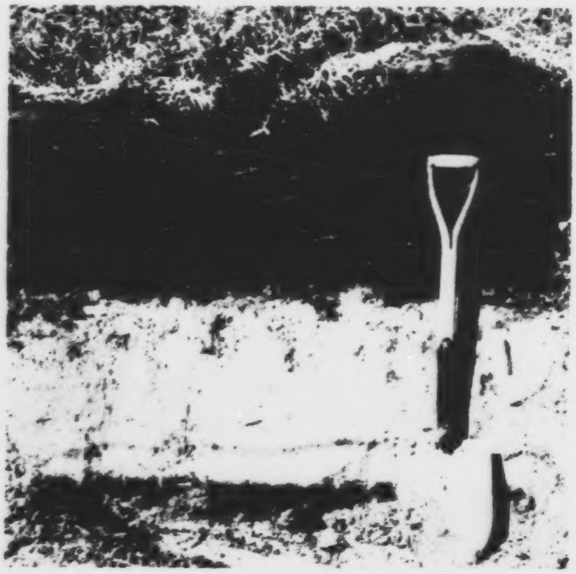

Figure No. 49
Half-Bog soil. Fen peat 18 inches deep.

RIVERDALE ASSOCIATION:

The Riverdale soils are very juvenile, highly fertile soils found on the terraces and flood plains along the Red, Assiniboine, Seine, Roseau, and Rat rivers. The soils are recent alluvial deposits with feeble or no development of soil horizons, greyish brown throughout, and ranging in texture from fine sandy loam to silty clay. These grey brown deposits are naturally under fairly dense deciduous forest consisting of elm, basswood, ash, cottonwood, Manitoba maple, etc. Organic matter derived from the tree growth may be present at the surface but, as the thin leaf mat is often covered by alluvial sediments during subsequent inundation, the cross section of the soil profile shows numerous thin bands of organic residue interlayered with the variable textured grey brown alluvium. The Riverdale soils are slightly alkaline in reaction, and highly productive. (See Figure No. 47.)

The Riverdale soils may be used for the production of all classes of agricultural crops; they are especially suited for market gardening and small fruit culture. They also will support a wide variety of utility and ornamental trees. These soils may be rated as excellent or good to excellent with few natural problems, except that the river terraces are subject to floods during the winter-spring breakup and the soils require organic matter when garden or intertilled crops are grown continuously.

OAKVILLE ASSOCIATION:

The Oakville soils are juvenile or immature soils in varying stages of development. These soils have been developed on fine to medium textured alluvial sediments deposited as flood plains by overflow from the Assiniboine and other rivers. There is a progressive gradation in the soil texture and in the degree of soil profile development from the stream banks to the margin of the alluvial deposits. The soil textures grade from silty clay loam through silty clay to clay. The soils immediately adjacent to the stream channels and on the river terraces which are subject to periodic flooding, are recent alluvial deposits with little or no soil profile development. These recent alluvial deposits are designated as Riverdale soils. However on the flood plains away from the stream channels some soil profile development has taken place, and these soils have been designated as Oakville soil association.

The surface horizon of the dominant or well to intermediately drained Oakville soil is grey to very dark grey in color, and ranges from silty clay loam to clay in texture. The surface soil is neutral to slightly alkaline in reaction and is usually friable and porous. The underlying materials are light brownish grey in color, silty clay loam to clay in texture, friable, porous, somewhat iron stained and moderately calcareous. The alluvial sediments are underlain by lacustrine clay deposits of glacial Lake Agassiz which retard sub-drainage so that the subsoils tend to be excessively moist. (See Figure No. 48.)

The associated soils include intermediately drained, poorly drained, slightly degraded, and alkalinized associates. The intermediately drained soils are similar to the better-drained soils in character but contain a somewhat higher percentage of lime carbonate. Local areas under woods may show some degradation but because the soils are comparatively young no strongly developed degraded types are found. The poorly drained soils may be Meadow or Peaty Meadow soils which are strongly iron stained and calcareous throughout the profile. The halomorphic soil associates may be either poorly drained salinized soils or weakly developed alkalinized soils. The latter are usually clay in texture.

The better-drained soils of the Oakville association are excellent agricultural soils for all grain crops, corn, roots, grasses and legumes, and garden crops. However, the control of horsetail (Equisetum arvense) is a problem on the less well-drained areas where the subsoils are moist and the substrate is responsible for arrested internal drainage. In some years difficulty has been reported in growing good crops of barley. Both of these problems are affected directly or indirectly by wet subsoil conditions especially during wet years. Under the wet subsoil conditions, nitrification appears to be slow in the early spring so that in the early stages of growth, barley may be pale green to yellowish green in color. Adequate drainage and the application of nitrogen along with phosphate at the time of seeding is required, on the wet subsoil sites, to offset the low availability of nitrogen in the early spring. The poorly drained and salinized soils are subject to periodic flooding from the streams and are more suited to hay and pasture use. These soils can be reclaimed for general agricultural use if flooding is prevented and adequate drainage is provided.

ALLUVIUM:

Undifferentiated recent alluvial deposits of variable type are found along various streams such as the Brokenhead River, the Seine River, the Rat River, and their tributary streams. Here, in the South-Eastern Complex the channels are comparatively shallow, and the streams flood the surrounding area in the spring of the year or during seasons of high rainfall. Both the Roseau and the Rat rivers flow through extensive areas of low-lying soils which are frequently covered with water, but appreciable deposits of alluvium are restricted to the vicinity of the streams where flooding is of annual occurrence.

This alluvium ranges in texture from sand to silty clay. No horizon differentiation or soil profile development is apparent, and the deposits are of extremely variable composition and origin. In some cases layers of alluvium may be interbedded with layers of peat. The alluvium deposits are generally alkaline, and quite fertile, and they should be productive if adequate drainage were provided. Under the present conditions these areas may be used advantageously for hay production and grazing. Some grain growing has been attempted at various points but such attempts have been successful only in seasons when floods were not an inhibiting factor.

ORGANIC SOILS:

The soils that have been designated and mapped as Half-Bog and Bog soils are organic deposits, or accumulations of plant remains, that have been formed as peat under hydromorphic (water-logged or excessively wet) and anaerobic (not sufficient air) conditions. The peat deposits vary in appearance and physical condition depending on the type of vegetation from which the peat was derived, and on the degree of decomposition that has taken place.

Peats can be differentiated as: (a) sedimentary peat, or fine muck and jelly-like deposits that have settled or precipitated in ponded waters; (b) fen peat, or accumulations of aquatic plants, reeds, sedges and grasses which have filled in areas that were formerly ponds, and may be in either a fibrous or crumbly condition, depending on the degree of decomposition that has taken place; (c) woody peat, or the remains of trees and shrubs that invaded earlier peat formations; (d) moss peat, or the remains of mosses and allied plants and which is generally fibrous or felty; (e) mixed peats, in which the various forms of peat were found superimposed one over the other. Because of the excessively wet conditions that prevail where these various plant remains are deposited, decomposition is either slow or inhibited. Varying degrees of anaerobic and aerobic decomposition however do occur depending on the degree of saturation that prevails, or on the degree of aeration that follows when dry seasons or other factors result in improved drainage. A further factor involved in the formation of peat is the chemical reaction and composition of the swamping waters. Thus the peat and the saturating waters may be acid, neutral, or alkaline in reaction, and hence the reaction as well as the type of peat, affects the plant species that are found growing on the respective sites.

In the reconnaissance survey of the Winnipeg-Morris map areas the organic soils or peats were differentiated on the basis of depth, and vegetative cover. Where the peat was 10 to 30 inches in depth it was classified and mapped as Half-Bog soil, where the peat was over 30 inches in depth it was classified and mapped as Bog soils. A suitable symbol was used on the soil map to indicate black spruce and tamarack swamps, and a conventional symbol was used to indicate marsh areas. (Where the peaty surface covering was only a few inches in thickness and a hydromorphic soil profile had developed in the underlying mineral materials, the soil was classified as a Peaty Meadow associate of the soil association in which it was occluded.)

(i) Half-Bog Soils:

Where Half-Bog soils occupy hydromorphic sites in the Blackearth zone they are invariably of the fen peat type. In the Grey - Black soil zone, although the fen type of peat predominates, some of the Half-Bogs have been invaded by tamarack and black spruce. In the northern portion of the Grey Wooded soil zone in the Winnipeg-Morris map areas, black spruce and tamarack with associated growths of leatherleaf and moss are the dominant type of vegetation on mixed fen and woody types of peat. In the southern portion, wet-land grasses, sedges and reeds are intermixed with clumps of black spruce and tamarack, and fen rather than woody peat predominates. (See Figure No. 49.)

Under virgin conditions, Half-Bog soils of the fen peat type are of little economic value, the native grass-like plants are of poor quality and the peat soil is commonly too wet for profitable hay or pasture use. With controlled drainage and with the introduction of suitable grasses and fertilizer these soils can be reclaimed for use as hay, and pasture land, and for the production of other crops that are grown for leaf and stem rather than for grain. Some grass seeds such as timothy may be produced satisfactorily if suitable fertilizers are used. Drained Half-Bog soils or peats are a serious fire hazard, hence all drainage should be controlled by check dams installed in the drainage channels, and water levels, drains and checks should be kept under close supervision. Burning of the peat, after drainage has been installed, is often practised but this practice, in most cases, is very unwise. If the peat is sufficiently dry and a reasonably "clean" burn is obtained, the underlying mineral material is exposed. This material may be stony, unproductive and deficient in organic matter. The ashes from the burnt peat present physical problems, but they may be of some fertilizing value for one or two years. Inevitably burnt-over peat land requires drainage maintenance, and in addition, organic matter is required in the form of manure or hay and pasture crops before such burnt-over areas can give maximum production. The Half-Bog soils that are under black spruce and tamarack may be conserved and maintained as woodlots. The Black spruce is especially suited for pulpwood and tamarack can be used for fence posts.

(ii) Bog Soils:

The Bog soils or deep peats occur chiefly in the excessively hydromorphic sites within the Grey Wooded, and to a lesser extent in the Grey - Black soil zones. These organic soils tend to be saturated or water-logged almost continuously. Poor stands of black spruce and tamarack are dominant except in the southern portion where sedges, reeds and swale grasses are more prevalent. Normally the deep Bog soils are nonagricultural, but where drainage has been improved and the surface peat decomposed to mull, timothy and reed canary grass may be grown profitably for seed production. However, until fibrous and woody forms of peat have undergone considerable decomposition they may be classed as unsuited for agricultural use.

(2) SUMMARY TABLE OF THE SOIL CHARACTERISTICS:

A summary description of the chief characteristics of the dominant soils, together with a brief notation of the associated soils, the soil parent materials, the prevailing texture, the native vegetation, the topography, the drainage, the natural fertility, the approximate acreage, the indicated suitability for agricultural use, and the major soil problems, are shown in tabular form in Table No. 6. This summary table will be found valuable for general use in interpreting the accompanying map. The summary description is necessarily generalized; when used locally, the information thus presented may require the qualifications and elaboration given under the foregoing section, (1) "General Soil Descriptions".

C. LAND CLASSIFICATION:

(1) ESTIMATED SUITABILITY OF SOILS FOR AGRICULTURAL USE:

The estimated suitability of the soils of the Winnipeg-Morris area for various purposes is shown in tabular form in Table No. 7. This table was made from general observations and from a study of the characters expressed in the respective soil profiles. It is not based on crop yield data (which are not available) but it represents the considered opinion of the soil surveyors, based on the characteristics of the respective soils and on other natural phenomena.

TABLE NO. 6 -- SUMMARY OF THE SOIL CHARACTERISTICS, INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA.

TABLE NO.-6 — SUMMARY OF THE SOIL CHARACTERISTICS, INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA.

Soil Zone or Subzone	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and PrevailingTexture"
Black-earth Zone	RED RIVER (i)Red River clay	Representative Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Very dark grey to black clay, 8 to 10 inches thick; weakly prismatic macrostructure breaks readily into granular aggregates; very plastic and very sticky when moist, hard when dry; neutral in reaction. "B" Horizon: Dark greyish brown clay, 4 to 6 inches thick; granular; very plastic and sticky when wet, very hard when dry; slightly alkaline in reaction. Thin tongues of black soil intrude into this horizon from above. "Ca" Horizon: Light brownish grey clay, 8 to 10 inches thick; weakly granular; very sticky and very plastic when wet, hard when dry; finely flecked with lime carbonate concretions. "C_1" Horizon: Greyish brown clay; fragmental to cloddy; very sticky and very plastic when moist, very hard when dry; alkaline, contains some lime carbonate concretions. Dominant Soil Associate (PH) Intermediately drained "A" Horizon: Black to very dark grey clay, 6 to 12 inches thick; weakly prismatic macrostructure breaks into fragmental to coarse granular aggregates; very sticky and very plastic when wet, very hard when dry; neutral. Grades either through a weak accumulation of lime carbonate or directly into:- "C_1" Horizon: Greyish brown clay with an olive cast when moist, massive macrostructure and weakly expressed fragmental to granular microstructure; very sticky and plastic when wet, very hard when dry; alkaline in reaction; may contain lime carbonate and limonite concretions. This associate includes local areas of soil that are more or less alkalinized which if separated would be designated as Morris clay.	Well-drained associates: Blackearth soils (P). Grey-Black soils (Pw) Intermediately drained associates: Blackearth - Meadow soils (PH). Calcic Blackearth - Meadow soils (PH_{Ca}). Alkalinized soils (G). Degrading Alkalinized soils (Gd). Poorly drained associates: Degrading Meadow soils (H_{G-}). Meadow soils (H). Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Gs}). Peaty Meadow soils (Ho).	Lacustrine clay.
	(ii) Osborne Clay	Poorly drained associate (H) "A" Horizon: Very dark grey clay, 3 to 6 inches thick; amorphous appearing mass of feebly expressed granular aggregates; very sticky and very plastic when moist, very hard when dry; alkaline. (Top few inches may be mucky.) Tongues into:- "Ca" Horizon: Light brownish grey clay; weakly granular; very sticky and very plastic when moist, hard when dry; flecked with limonite and lime carbonate concretions, and sometimes contains marly pockets. "C_1" Horizon: Grey, and olive grey to brownish grey clay; amorphous mass showing weakly granular aggregates; very plastic and very sticky when moist, hard when dry; frequently highly carbonated and iron stained.		
	(iii)St. Norbert clay	Wooded associate (Pw) "Ao" Horizon: Very dark brown leaf mat, partly decomposed;neutral to slightly acid. "A_1" Horizon: Very dark grey clay up to 2 inches thick; finely granular; friable; slightly acid in reaction. "A_2" Horizon: Dark grey clay 1 to 4 inches thick; irregular granular structure increasing in size with depth; sticky when wet, firm when dry; acid in reaction. "B_1" Horizon: Dark grey brown clay 6 to 9 inches in depth; nuciform, tendency to be cloddy; very hard when dry, extremely firm when moist; slightly acid in reaction. "B_2" Horizon: Very dark greyish brown clay, 8 to 12 inches in depth; massive macrostructure shows finely granular microstructure; very hard when dry, tough and plastic when moderately moist, and sticky when wet; neutral reaction; grades into:- "C_1" Horizon: Dark brown to dark greyish brown clay; massive macrostructure with finely fragmental microstructure;very hard when dry, plastic and sticky when moist; effervesces and contains concretionary lime carbonate.		
	HORNDEAN COMPLEX	A complex of relatively immature soils developed on variable textured sediments which have been deposited over the lacustrine clay in the western portion of the Lake Agassiz basin. Considerable profile variation occurs. The relatively mature soils have a very dark grey "A" horizon 6 to 15 inches in depth which grades through a grey to light grey "Ca" horizon into a light grey "C" horizon which lies over a lacustrine clay subsoil. The more immature soils are characterized by up to four feet or more of very dark grey soil material of clay texture interspersed by bands of organic material or by layers of lighter textured sediments. All intermediate variations occur between these profile types. The soils in the complex are salinized or alkalinised to a greater or lesser degree.	Intermediately drained associates: More or less alkalinized soils (PH_G). Poorly drained associates: Meadow soils (H). Saline Meadow soils (H_{Gs}).	Alluvial and stream outwash sediments. Surface texture is clay.

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Tall prairie grasses, and meadow prairie grasses and herbs. Aspen and willow may occur on the intermediately drained sites.	Slight ridges and micro-undulations in a comparatively level plain. Drainage is fairly good, but internal drainage is slow due to fine texture; hence provision for maintaining surface drainage and for improving internal drainage is required under arable culture.	High. Medium high, but physical condition of the clay may be a problem in either excessively wet or excessively dry years.	791,936 % 22.32	Good agricultural soils for all regional crops; especially suited to grain production and grass-alfalfa mixtures, but stock raising may be somewhat restricted by limited supply of well water.	Slow drying of soil in wet seasons. Tillage and management practices suitable to these soils are required to keep arable soils in a friable condition. Limited supply of good well water.
	Topography level. Drainage is very slow and must be improved by adequate surface drainage channels.			Adaptable to grain farming and grass culture. Not as suitable for intertilled crops as the better-drained soil.	Difficult and heavy tillage. Surface water ponds in the micro-depressions in wet seasons. Organic matter often inadequate for best physical condition Limited supply of good well water.
Swale grasses and sedges. Aspen, black poplar, willows and dogwood in many areas east of the Red River.	Topography flat. Drainage is very slow; requires surface drainage by open ditches Ponding often occurs in the spring or after heavy rainfall.	Moderate, except in excessively wet or excessively dry years when poor physical condition adversely affects productivity	805,555 (Peat) (phase) 24,934 % 22.70 % 0.70	If adequately drained can be utilized for grain farming and livestock production. Requires adequate drainage by open drains. Legumes are liable to kill out because of excess water in the spring. However the production of grasses and if possible legumes, and the return of combine straw to the land should be practiced. Least productive of the Red River soils. Not generally suitable for root crops such as sugar beets.	Systematic drainage is necessary. An inadequate supply of organic matter for the best physical condition of the soil. High-lime and salinized areas. Limited supply of good well water and high cost of drainage ditch maintenance.
Chiefly oak and aspen, with hazel, saskatoon and dogwood as undergrowth.	Topography is smooth; this soil type generally occurs above and adjacent to stream channels on well-drained sites. Internal drainage is sluggish and impeded by a tough "B" horizon.	Medium high but the physical condition of the clay is always a problem.	38,682 % 1.09	Suited to grain production and grass-legume mixtures. Root crops are often adversely affected by the tough "B" horizon	Heavytillage and compact nature of the subsoil. Requires organic matter to improve the physical condition of the soil.
Meadow prairie grasses and herbs with associated alkali-tolerant plants.	Flat to level with some slight ridges surface run-off is slow and internal drainage is sluggish due to the flat topography and clay texture. There is some danger of surface flooding by flash run-off from the Manitoba escarpment.	Moderately good in non-salinized areas. Low to medium in saline sections. Physical condition of the clay may be a problem.	51,840 % 1.46	Fairly good land for grain crops. Grass-legume mixtures should be included in a crop rotation to help maintain fertility and soil tilth.	Poor surface and internal drainage. Difficult tillage due to clay texture and alkalinized structure of the soils. Salinization of depressional sites. Poor quality of well water.

(Cont'd.)

TABLE NO. 6--SUMMARY OF THE SOIL CHARACTERISTICS,
INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA. (Cont'd.)

Soil Zone or Subzone	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture
Black-earth Zone	**MARQUETTE**	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Very dark grey to black, clay or heavy clay loam; 8 to 10 inches thick; weakly developed prismatic clods of irregular form which break into medium granular aggregates; very hard when dry, moderately plastic and sticky when moist; neutral to slightly alkaline. "B" Horizon: Dark greyish brown clay to heavy clay loam, 6 to 14 inches thick; medium granular; hard when dry, moderately plastic and moderately sticky when moist; alkaline. May be flecked with lime carbonate. "C" Horizon: Light brownish grey clay to heavy clay loam, 10 to 18 inches thick; finely granular to cloddy; hard when dry, moderately plastic and sticky when moist; strongly alkaline. ("C" horizon may be absent.) Grades into:- "D1" Horizon: Light grey modified till of clay texture, more or less marbled. Contains small stones, strongly alkaline. "D2" Horizon: Unmodified calcareous till.	Intermediately drained associates: Blackearth-Meadow soils (PH). Calcic Blackearth - Meadow soils (PH_{Ca}). Salinized soils (G_s). Alkalinized soils (G). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Gs}). Peaty Meadow soils(Ho	Thin mantle of lacustrine clay over till. Surface textures range from clay to heavy clay loam.
	FORT GARRY	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Very dark grey clay, 7 to 10 inches thick in normal position, (tongues may intrude 20 inches downward); prismatic; very hard when dry, moderately plastic and sticky when moist; neutral to slightly alkaline. "Ca" Horizon: Light grey, marly, very fine sandy clay loam to silty clay 5 to 8 inches thick; weakly granular; friable; very calcareous. "C" Horizon: Light grey to pale yellow, very fine sandy clay loam to silty clay; more or less stratified; friable; very calcareous. (This horizon may be up to 5 feet thick). "D" Horizon: Lacustrine clay.	Intermediately drained associates: Degrading Blackearth soils (P-PHw). Blackearth-Meadow soils (PH). Alkalinized soils (G). Degrading Alkalinized soils (Gd). Poorly drained associates: Meadow soils (H). Saline Meadow soils (H_{Gs}).	Deltaic and lacustrine deposits. Dominantly clay surfaced textures (but may range from silty clay loam to clay) over more or less stratified pale yellow very fine sand and silty clay which rests on lacustrine clay.
	RED RIVER-EMERSON TRANSITION	A complex of soils developed on Red River and Emerson soil parent materials. Both Red River and Emerson types are intermixed with soils that are intergrades between these two associations. The dominant soils are well to intermediately drained. Small areas of halomorphic and poorly drained soils occur in lower sites.	Intermediately drained associates: Blackearth-Meadow soils (PH). Alkalinized soils (G). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Saline Meadow soils (HGs)	Deltaic and lacustrine deposits. Surface textures range from silty clay loam to clay.
	EMERSON Silty loam to silty clay loams	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Very dark grey silt loam to silty clay loam, 5 to 15 inches thick; finely granular; friable; alkaline. (Approximately 5 inches of dark greyish brown "B" horizon is evident in some well-drained sites.) Tongues of surface material in the heavy textured soils may extend 2 feet downward. "Ca" Horizon: Grey marly horizon, 6 to 12 inches thick; silt loam to silty clay loam; crumb structure; friable. "C" Horizon: Light grey to pale yellow silt loam to silty clay; weakly granular; friable; strongly calcareous; iron stained and frequently contains gypsum concretions. "D" Horizon: Lacustrine clay.	Intermediately drained associates: Degrading Blackearth soils (P-PHw). Blackearth-Meadow soils (PH). Alkalinized soils (G). Poorly drained associates: Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Gs}).	Yellowish deltaic and lacustrine deposits. Surface textures dominantly silty clay loam but range from silt loam to silty clay.
	Silty clays	Soils similar to the silt loams and silty clay loams but heavier in texture and often more poorly drained.		
	LAKELAND Fine sandy loams	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Dark grey to very dark grey fine sandy loam to silt loam, 5 to 12 inches thick; structureless to fine granular; very friable; moderately alkaline. Grades irregularly into:- "Ca" Horizon: Light grey to white loamy fine sand to very fine sandy loam, 6 to 9 inches thick; structureless; loose to extremely friable; calcareous. "C" Horizon: Very pale brown to light grey, fine-sand to silt loam; structureless to crumb structure; loose to friable; calcareous; iron stained. (Usually laminated.) "D" Horizon: Very pale brown to light grey, lake-washed calcareous till is encountered from 2 to 6 or more feet below the surface. A gravelly or cobbly lens is present at the junction of the till and water-laid deposits in some profiles.	Intermediately drained associates: Blackearth-Meadow soils (PH). Salinized soils (Gs). Poorly drained associates: Meadow soils (H). Saline Meadow soils (H_{Gs}). Peaty Meadow soils (Ho) Small occluded areas of Woodlands complex. (See below.)	Thin deltaic and outwash deposits underlain by till. Surface textures range from a fine sandy loam to a silty clay loam.
	Clay loams to clays	Soils with profiles similar to the fine sandy loams but heavier in texture and generally more poorly drained.		

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Tall prairie grasses with associated herbs and some invasion of deciduous woods on better-drained sites. Meadow prairie grasses, sedges, reeds and willows on poorly drained sites. Alkali-tolerant plants on saline areas.	Smooth level topography with micro-relief. Surface run-off is variable depending on the site. Ditches are improving the condition. Internal drainage is moderate on higher positions and very slow in lower areas.	Medium high in non-salinized areas. Low to medium in saline soils.	167,859 % 4.73	Good for grain and grasses. Requires grasses and legumes to improve soil tilth and drainage. Except in the better-drained sites it is not suitable for root crops.	Drainage is required. Salinity often strong enough to inhibit plant growth. Some soils are becoming intractable because of continued fallow-grain culture.
Prairie and meadow prairie grasses and herbs. Some alkali-tolerant plants in local saline areas. Unthrifty, scrubby aspen and oak have invaded much of this association.	Level with micro-relief. Drainage imperfect, some localised ponding occurs in wet seasons.	Moderately high, but many plants show chlorosis due to high lime-subsoil.	36,890 % 1.04	Suitable for regional grain crops in well-drained sites. Limited use for garden and intertilled crops.	Thin surface soil. Generally too high in lime for certain trees, shrubs and flowers. Salinity is common in low sites. Limitation of good well water. In some areas artificial drainage is required.
Tall prairie grasses and herbs.	Level with micro-relief.	Generally good.	36,915 % 1.04	Good for grain, grasses and legumes; moderately good for root crops.	Local areas of high-lime soil with problems similar to the Emerson association. Also drainage may be required in lower sites.
Prairie and meadow prairie grasses and herbs. Alkali-tolerant plants on salinized sites.	Level with smooth gentle ridge-like elevations, and micro-depressions. Surface drainage fairly good but subsoil is usually moist to wet.	Good to fairly good, except for excess lime and salinity in the wetter sites but this varies with wet and dry seasons.	145,971 % 4.12	Suitable for all regional crops including grains, roots, corn, sunflowers and forage crops, (except on the associated hydromorphic and salinized sites, and in the case of plants that do not thrive under high-lime conditions or alkaline conditions.	Poor internal drainage in wet seasons because of a clay substrate. Salinity in the depressions. Somewhat high in lime due to the rise of ground-water lime by capillary action. Somewhat susceptible to soil drifting unless the surface has a protective covering of crop or trash.
Meadow prairie grasses and herbs with some recent tree invasion in the better-drained sites. Reeds and sedges with clumps of willow in poorly drained sites and alkali-tolerant plants in salinized areas.	Level to very gently sloping terrain. Internal drainage is retarded due to an impervious clay and boulder-till substrate. Many wet areas and some ponding occur. A perched water table may occur in wet seasons.	Medium.	34,586 % .98	Suitable for mixed farming, requires grasses and legumes in the crop rotation. Phosphate fertilisers are needed to offset low availability of phosphorus due to the high-lime nature of the soils.	High lime content. Low availability of phosphate. Susceptible to wind erosion. Light textured soils are low in water-retention capacity.

TABLE NO. 6 — SUMMARY OF THE SOIL CHARACTERISTICS,
INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA. (Cont'd.)

Soil Zone or Subzone	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture"
Blackearth Zone	SPERLING	Dominant Soil Associate (P) Well drained "A" Horizon: Very dark brown very fine sandy loam to silty clay, 10 to 16 inches thick;structureless to granular;very friable to hard; slightly alkaline. "Ca" Horizon: Grey very fine sandy loam to silty clay,5 to 12 inches thick;structureless to granular;friable to hard; calcareous. "C_1" Horizon: Light grey to light yellowish brown fine sandy loam to silty clay;structureless to finely granular;very friable to hard;calcareous. (At varying depths,a buried meadow soil similar to the poorly drained Red River clay may be found.	Intermediately drained associates: Blackearth-Meadow soils (PH). Calcic Blackearth-Meadow soils(PH_{Ca}). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}).	Natural levee and stream overwash. Surface textures grade from a very fine sandy loam to a silty clay.
	STEINBACH	Dominant Soil Associate (PH) Intermediately drained "A" Horizon: Black to very dark grey fine sandy loam to fine sandy clay loam,6 to 12 inches thick;medium granular;friable;alkaline. "Ca" Horizon: Light grey to grey fine sandy loam to fine sandy clay loam 4 to 9 inches thick;weakly developed fine granular aggregates;very friable;strongly calcareous. "C" Horizon: Light brownish grey to pale yellow fine sand to fine sandy loam 1 to 12 inches thick;structureless;loose; calcareous;iron stained. "D_1" Horizon: Light brownish grey to dark greyish brown heavy clay loam to clay (laminae and pocket-like deposits of very fine sand often present),12 or more inches thick; granular;very hard when dry,very plastic and sticky when moist;alkaline; contains iron concretions and frequently gypsum crystals at the sand and clay junction. "D_2" Horizon: White to pale brown till or eroded till at 30 or more inches from the surface.	Intermediately drained associates: Blackearth-like soils (P-PH). Degrading Blackearth soils (P-PHw). Degrading Blackearth-Meadow soils (PHw). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Sa}).	Two or more layers of outwash and lacustrine material on till.Surface textures range from fine sandy loam to fine sandy clay loam.
	ALTONA Fine sandy loams	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Very dark grey very fine sandy loam,10 to 20 inches thick;structureless to weakly developed crumb aggregates; very friable, porous;neutral to slightly alkaline. "B" Horizon: Grey brown to light yellowish brown loamy fine sand to very fine sandy loam, 7 to 14 inches thick;structureless;extremely friable,porous; alkaline. "Ca" Horizon: Pale brown to light grey fine sand to very fine sandy loam, 8 to 15 inches thick;structureless;extremely friable;calcareous. "C_1" Horizon: Light yellowish brown fine sand to very fine sandy loam;structureless;loose to extremely friable,porous; moderately calcareous;frequently contains lime carbonate concretions, and may be slightly iron stained or contain some gypsum crystals. (Sandy textured profiles are often badly intermixed by gophers.)	Intermediately drained associates: Blackearth-Meadow soils (PH). Calcic Blackearth - Meadow soils(PH_{Ca}). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Sa}).	Fine sandy lacustrine sediments deposited in the shallow waters of the western portion of glacial Lake Agassiz.Surface textures dominantly fine sandy loam but very fine sandy clay loams are also present.
	Very fine sandy clay loams	Soils similar to the fine sandy loams but they are finer in texture and are stronger in structural aggregation. The horizons of this type are not quite as deep ar those of the fine sandy loams.		
	AGASSIZ	Dominant Soil Associate (P) Well drained "A" Horizon: Dark grey loamy coarse sand to sandy loam,4 to 8 inches thick;structureless;loose;slightly alkaline. "B" Horizon: Dark brown to brownish grey loamy coarse sand to coarse sandy loam. 3 to 7 inches thick;structureless;loose; moderately alkaline. "Ca" Horizon: Light grey to pale brown loamy sand and gravel; weakly cemented with lime carbonate;strongly alkaline. "C" Horizon: Light yellowish brown stratified sand and gravel.	Intermediately drained associates: Blackearth-Meadow soils (PH).	Beaches of glacial Lake Agassiz invariably composed of coarse skeletal material. Surface textures dominantly loamy coarse sand to light sandy loam.

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Tall prairie grasses and herbs with associated meadow grasses.	Level topography with slight levee effect adjacent to the dry or intermittent stream channels. Drainage is generally good.	High	14,720 % .42	Good to excellent for all regional crops, i.e.; grain, grasses and legumes, sugar beets and other intertilled crops.	Some soil drifting on sandy textured soils. Occasional flood hazard from flash run-off. Limited supply of good well water.
Tall prairie grasses and herbs with some trees in the better-drained sites. Reeds, sedges, meadow grasses and clumps of willow in the poorly drained sites.	Level to very gently sloping terrain. Internal drainage is retarded by an impervious oulder-till subsoil.	Medium high to medium.	19,968 % .56	Better-drained soils are suitable for the production of all regional crops. They are friable, easily worked, and are suited to the production of diversified crops such as corn, sugar beets, vegetables, etc. Poorly drained soils can be utilised for arable culture if drainage is provided.	Poor subsoil drainage. Local salinity. Some wind erosion on exposed fields. Lime content generally too high for optimum growth of some horticultural crops that require an acid soil reaction.
Tall prairie grasses and meadow prairie grasses and herbs	Smooth to level with gentle ridge-like undulations. Surface drainage is good. Soils are porous but heavy substratum may be responsible for an aperiodic water table.	High.	52,634 % 1.48 42,547 % 1.20	Fairly good to good agricultural land. Growth is early and rapid but the soils are susceptible to soil drifting. Good growth site for corn, sugar beets and vegetable crops for canning. Grasses and legumes are essential to keep the soil in good physical condition. Manure and grasses are needed to keep up organic matter. Trash cover should be used extensively to decrease the hazard of wind erosion.	Soil Drifting. Reduction of organic matter through loss by wind erosion. Low water-retention capacity of light soils. Difficulty of managing of light soils in dry years due to feeble structure. Local areas with arrested drainage may be salinized or calcareous.
Generally mixed prairie grasses and herbs, (grama grass, artemesia) but occasional scrubby aspen and oak may be found.	Typical rounded beach ridges. Drainage is rapid but local poorly drained areas may result from lateral seepage.	Generally low.	9,702 % .27	Not suitable for general agricultural crops. May grow occasional fair crops of rye. Use as pasture is limited due to its low carrying capacity. Source of gravel for roads, etc.	Coarse texture. Low water-retention capacity. Soil drifting if exposed. Damming effect on country drainage because ridges run parallel to the contours.

(Cont'd.)

TABLE NO. 6—SUMMARY OF THE SOIL CHARACTERISTICS, INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA (Cont'd.)

Soil Zone or Subzone	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture"
Blackearth Zone	KITTSON (i)Shallow phase	Soils developed on up to 15 inches (±) of water-sorted sediments over calcareous till. Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Very dark grey fine sandy loam to fine sandy clay loam,3 to 4 inches thick;fine granular to structureless; extremely friable to friable;and slightly alkaline. "B" Horizon: Dark grey fine sandy loam to fine sandy clay loam, 5 to 8 inches thick;medium granular;friable;alkaline in reaction. "Ca" Horizon: Light grey to grey lime carbonate accumulation horizon containing an admixture of sand, gravel and small cobbles;4 to 6 inches thick. "D" Horizon: Very light grey to pale brown calcareous till. Usually laminated and modified in the upper portion of the till.	Well-drained associates: Blackearth soils (P) Grey-Black soils(Pw) Intermediately drained associates: Blackearth-Meadow soils (PH). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Meadow Podzols(Hd). Peaty Meadow soils (Ho).	Thin sandy surface deposits over water-worked till from which stones may extrude into or on top of the surface.Surface textures range from fine sandy loam to fine sandy clay loam.
	(ii)Deep phase	Soils developed on 16 to 30 inches (±) of water-sorted sediments over calcareous till Dominant Soil Associate (P-PH) Well to Intermediately drained "A_{11}" Horizon: Very dark grey heavy fine sandy loam,3 to 5 inches thick;structureless,very friable;neutral. "A_{12}" Horizon: Dark grey fine sandy loam,2 to 3 inches thick; structureless;very friable;neutral. "B_2" Horizon: Very dark grey heavy fine sandy loam,5 to 10 inches thick;weakly developed granular structure,friable, weakly cemented; neutral to slightly alkaline. Grades into:- "B_3" Horizon: Light greyish brown loamy fine sand,6 to 9 inches thick;weakly cemented;very friable; moderately alkaline. "Ca" Horizon: Light grey calcareous horizon of gravel and sand 3 to 5 inches thick. "D_1" Horizon: Light grey calcareous sandy modified till. The laminated material breaks into fragmental particles. "D_2" Horizon: Very pale brown calcareous modified till, heavy sandy loam in texture; laminated and slighly iron stained.	Well-drained associates: Blackearth soils (P). Grey-Black soils (Pw). Intermediately drained associates: Blackearth-Meadow soils (PH). Degrading Blackearth-Meadow soils(PHw). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Meadow Podzols (Hd). Peaty Meadow soils (Ho).	Sandy deposits on water-worked till. Surface texture fine sandy loam.
	SPRINGBANK	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Dark grey to very dark grey fine sandy loam, 8 to 12 inches thick; structureless;very friable; neutral to slightly alkaline. "B" Horizon: Very dark brown to greyish brown fine sandy loam, 5 to 12 inches thick;structureless;very friable; neutral to slightly alkaline. Grades into:- "Ca" Horizon: Light brownish grey to light grey fine sandy lime accumulation horizon, 4 to 10 inches thick;structureless; loose; alkaline. "C" Horizon: Pale yellow to brownish yellow fine sand;structureless; loose; alkaline; may be iron stained. "D" Horizon: At 30 or more inches water-sorted sediments are underlain by light grey to pale brown calcareous till.	Well-drained associates: Blackearth soils (P). Grey-Black soils(Pw). Intermediately drained associates: Blackearth-Meadow soils (PH). Degrading Blackearth-Meadow soils (PHw). Calcic Blackearth-Meadow soils (PH_{Ca}). Poorly drained associates: Meadow soils (H). Meadow Podzols (Hd). Calcic Meadow soils (H_{Ca}). Peaty Meadow soils (Ho).	Sandy deposits over 30 inches in depth underlain by water-worked till. Surface textures are dominantly fine sandy loam.
	WOODLANDS COMPLEX	A complex of shallow calcic blackearth-like or rendzine-like soils which are developed on surface deposits transitional between the parent materials of the Lakeland and Isafold associations. The shallow,very dark grey,granular "A" horizon grades into a strong lime carbonate accumulation which may be underlain by lacustrine materials over till or grade directly into till or eroded till. Surface textures vary from fine sandy loam to heavy clay loam.The degree of stoniness is variable depending upon the proximity of the underlying till to the surface.	Intermediately drained associates: Blackearth-like soils-(P-PH). Blackearth-Meadow soils (PH). Poorly drained associates: Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Sa}).	Thin lacustrine deposits over calcareous till. Surface textures range from a fine sandy loam to a heavy clay loam.
Grey-Black Transitional Zone	PEGUIS	Dominant Soil Associate (P-PHw) Well to Intermediately drained "Ao" Horizon: Dark brown leaf mat about 1 inch thick;neutral to slightly acid. "A_1" Horizon: Very dark brown clay intermixed with decomposed forest debris; 1 to 2 inches thick;friable;neutral to slightly acid. "A_2" Horizon: Dark grey clay,2 to 4 inches thick;granular; hard; neutral to slightly acid. "B" Horizon: Very dark greyish brown clay,7 to 8 inches thick; weakly developed column-like structure breaks into nutty aggregates;very hard when dry; neutral. Grades into:- "C" Horizon: Greyish brown clay to silty clay,6 to 18 inches thick granular; hard; alkaline; contains some limestone pebbles, carbonate concretions and may be iron stained. "D" Horizon: Grey to pale brown calcareous,unmodified till.	Intermediately drained associates: Degrading Blackearth-Meadow soils (PHw). Blackearth-Meadow soils (PH) Poorly drained associates Meadow soils (H). Meadow Podzols (Hd). Peaty Meadow soils (Ho).	Lacustrine clay 16 to 30 inches (±) in depth over calcareous till.

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Tall prairie grasses and herbs intermixed with, and under invasion by, deciduous woods on the better-drained sites. Meadow grasses, sedges, reeds and willows on poorly drained sites.	Very gently sloping topography with numerous large micro-depressions. Internal drainage is slow.	Low to medium.	6,579 % .19	Generally more suited to livestock production than general arable culture.	Local stoniness. Numerous poorly drained depressions. Wind erosion on cultivated fields.
Tall prairie grasses and herbs intermixed with and invaded by deciduous woods on better-drained sites. Meadow grasses, sedges, reeds and willows on poorly drained sites.	Very gently sloping topography with numerous large micro-depressions. Internal drainage is retarded by the till substrate. Many low wet areas occur.	Low to medium.	12,109 % .34	Limited largely to livestock production and dairying. Fair for grain. Legumes and grasses should be grown for maintenance of fertility.	Large areas of wet soils. Low water-retention capacity of surface soil under cultivation. Low organic matter content. Cultivated soil subject to wind erosion. Local stoniness.
Tall prairie grasses and herbs intermixed with and invaded by deciduous woods.	Very gently sloping. Relief is sufficient to provide good surface drainage although some low wet areas occur. Internal drainage is retarded by the underlying till substrate.	Medium to medium high.	20,761 % .59	Suitable for grain, hoed crops and forage crops. Grasses and legumes required in crop rotation to maintain fertility and reduce susceptibility to wind erosion.	Wind erosion on unprotected cultivated fields. Water-retention capacity of surface soil is low. May have a high water table in wet seasons.
Mixed meadow and prairie vegetation with islands of aspen and willow and with occasional oak on the low knolls.	Level to smooth very gently sloping topography, with numerous micro-depressions. Internal drainage may be slow due to the till substrate.	Medium.	52,301 % 1.47	Best suited for mixed farming. Improvement crops such as grasses and legumes are required to maintain soil fertility. Non-arable land can be utilized for hay and pasture.	Slow drainage. Local stoniness. Limy nature of the soil and salinity.
Deciduous woods consisting mainly of aspen and oak. Some tall prairie grasses and herbs intermixed with the woods.	Level topography. Moderately drained sites are dominant. Internal drainage is slow due to the clay texture of the parent materials.	High.	12,416 % .35	Well adapted to all regional crops; requires legumes and grasses to maintain tilth and fertility.	Slow internal drainage. Heavy tillage due to clay texture. Limited supply of good well water.

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TABLE NO. 6-- SUMMARY OF THE SOIL CHARACTERISTICS,
INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA. (Cont'd.)

Soil Zone or Subzone	Association	Profile Characteristics of typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture"
Grey-Black Transitional Zone	ZORA Fine sandy loams	Representative Soil Associate (P-PHw) Well to Intermediately drained (Minimal development of wooded soil characteristics) "A" Horizon: Dark grey sandy loam to very fine sandy loam, 6 to 11 inches thick;weakly developed fine granular structure; very friable;moderately alkaline.("B" horizon generally absent.) "Ca" Horizon: Light grey loamy fine sand to very fine sandy loam lime accumulation horizon,8 to 12 inches thick;structureless;extremely friable. "C" Horizon: Pale olive to light grey loamy fine sand to very fine sandy loam;structureless;very friable;calcareous; slightly iron stained. Grades at various depths into:- "D" Horizon: Pale brown to light grey calcareous modified till or glacio-lacustrine deposits.	Intermediately drained associates: Blackearth-like soils (P-PH). Degrading Blackearth-Meadow soils (PHw). Blackearth-Meadow soils (PH). Poorly drained associates: Calcic Meadow soils (H_{Ca}). Peaty Meadow soils (Ho).	Water-laid deposits of variable depth on till or glacio-lacustrine sediments.Surface textures range from sandy loam to very fine sandy clay loam.
	Loams to silty clays	Dominant Soil Associate (PHw) Intermediately drained (minimal development of wooded soil characteristics) "A" Horizon: Dark grey silty clay 5 to 10 inches thick; finely granular;friable;plastic;moderately calcareous; slightly iron stained. Grades into:- "Ca" Horizon: Light grey to white lime accumulation horizon, loam to silty clay in texture,4 to 12 inches thick; finely granular;friable;strongly calcareous.Fades into:- "C" Horizon: Light grey loam to silty clay;finely granular; plastic when moist,friable to hard when dry;moderately calcareous. "D" Horizon: Pale brown to light grey till or glacio-lacustrine deposits.	Intermediately drained associates: Degrading Blackearth soils (P-PHw). Blackearth-like soils (P-PH). Blackearth-Meadow soils (PH). Poorly drained associates: Calcic Meadow soils (H_{Ca}). Peaty Meadow soils (Ho)	Water-laid deposits of variable depth on till or glacio-lacustrine sediments.Surface textures range from loam to silty clay.
	SEMPLE	Dominant Soil Associate (P-PHw) Well to Intermediately drained "A$_0$" Horizon: Dark brown leaf and sod mat,½ to 1 inch thick; neutral. "A$_1$" Horizon: Very dark grey to black heavy clay loam to clay, ½ to 2 inches thick;medium granular; hard when dry, moderately plastic and moderately sticky when moist; neutral to slightly acid. "A$_2$" Horizon: Dark olive grey clay loam to clay, 1 to 2½ inches thick;medium granular;very hard;neutral to slightly acid. "B" Horizon: Greyish brown clay,5 to 10 inches thick;weakly developed prismatic columns break readily into small blocky aggregates;very hard when dry; neutral to slightly alkaline. May grade through a granular, greyish brown clay up to 4 inches thick, or directly into:- "Ca" Horizon: Light grey lime accumulation horizon of clay loam to heavy clay loam modified till;highly calcareous;contains some pebbles and small cobbles. "D" Horizon: Grey to pale brown calcareous reworked till.	Well-drained associates: Grey-Black soils (Pw). Blackearth soils (P). Intermediately drained associates: Degrading Blackearth-Meadow soils (PHw). Blackearth-Meadow soils (PH). Poorly drained associates: Meadow soils (H). Meadow Podzols (Hd). Peaty Meadow soils (Ho)	Thin lacustrine deposits 6 to 15 inches (±) in depth over calcareous reworked till.Surface textures range from clay loam to clay.
	PELAN (i)Shallow phase	Soils developed on up to 15 inches (±) of water-sorted sediments over reworked calcareous till. Dominant Soil Associate (P-PHw) Well to Intermediately drained "A$_0$" Horizon: Dark brown leaf and sod mat,1 inch thick; slightly alkaline. "A$_1$" Horizon: Dark grey sandy loam to fine sandy clay loam, 2 to 3 inches thick; structureless; very friable;neutral to slightly acid. "A$_2$" Horizon: Greyish brown loamy sand to fine sandy loam, 2 to 3 inches thick; structureless to weakly platy;very friable, neutral to slightly acid. "B" Horizon: Brown sandy loam to sandy clay loam,3 to 4 inches thick; weakly coarse granular to nutty; very friable; neutral. A cobbly lens or layer is commonly found at the base of this horizon. "Ca" Horizon: White to light grey lime accumulation horizon 3 to 4 inches thick,composed of cobbly resorted till which effervesces strongly. "D" Horizon: Very pale brown calcareous resorted till, laminated and stony.	Well-drained associates: Grey-Black soils(Pw). Blackearth soils(P) Intermediately drained associates: Degrading Blackearth-Meadow soils (PHw). Blackearth-Meadow soils (PH). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Meadow Podzols (Hd). Peaty Meadow soils (Ho).	Thin sandy deposits on reworked till.A lens or layer of cobbles commonly occurs between the sandy mantle and the till substrate. Surface textures range from sandy loam to fine sandy clay loam.
	(ii)Deep phase	Soils developed on 16 to 30 inches (±) of water-worked sediments over reworked calcareous till. Dominant Soil Associate (PHw) Intermediately drained "A$_0$" Horizon: Very dark grey leaf and sod mat, 1 inch thick; neutral. "A$_1$" Horizon: Very dark grey heavy fine sandy loam,1 to 2 inches thick;very friable; neutral. "A$_2$" Horizon: Dark greyish brown heavy fine sandy loam, 4 to 5 inches thick;weakly developed crumb structure;friable; neutral. "B$_2$" Horizon: Light yellowish brown loamy fine sand,4 to 5 inches thick;weakly cemented;very friable;neutral to slightly alkaline. "B$_3$" Horizon: Olive yellow fine sand,3 to 4 inches thick; structureless; weakly cemented; alkaline; iron stained. "Ca" Horizon: Pale yellow lime carbonate coated fine sand, 2 to 4 inches thick; structureless; weakly cemented when dry; calcareous. Grades into:- "C" Horizon: Pale yellow sand or calcareous gravel (sometimes cobbly). "D" Horizon: Pale yellow to pale brown calcareous resorted till; laminated; heavy sandy loam in texture.	Intermediately drained associates: Degrading Blackearth soils (P-PHw) Blackearth-like soils (P-PH). Blackearth-Meadow soils (PH). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Meadow Podzols (Hd). Peaty Meadow soils (Ho)	Sandy outwash deposits over reworked till.Surface textures are dominantly fine sandy loam.

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Woods consisting mainly of aspen, black poplar and spruce in the better-drained sites.Some elm, ash,maple and oak along the streams.Tamarack, black spruce, reeds and sedges in the wet sites.	Level topography with slight micro-undulations.Internal drainage is arrested by a boulder-till substrate.	Medium.	20,608 % .58	Well adapted to mixed farming. Requires legumes and grasses, etc., to supply organic matter and decrease susceptibility to wind erosion.	Imperfect internal drainage.Soil drifting. Maintenance of organic matter under arable culture. High lime content of the soil.
Similar to the vegetation on the fine sandy loams.	Level topography.Ponding may occur in micro-depressions. Impeded internal drainage caused by heavy texture of the soil and the till substrate.	Medium high.	62,592 % 1.77	Suitable for general agricultural crops and mixed farming.	Imperfect internal drainage.Surface drainage is required.High lime content of the soil. The maintenance of organic matter under culture.
Deciduous woods dominantly oak and aspen on better-drained sites.Meadow grasses,sedges and willow on poorly drained sites.	Level to very gently sloping. Internal drainage is slow due to the clay texture of the parent materials.Some ponding may occur.	Medium to high.	156,339 % 4.41	Arable soils are suitable for general agricultural crops. Stoniness may be a local factor in restricting cultivated acreage.Nonarable land is utilised mainly as pasture and woodlot.	Poor drainage in the lower positions.Local stoniness.
Deciduous woods of oak and aspen on better-drained sites.Meadow grasses,sedges and willows on poorly drained sites.	Very gently sloping topography crossed by occasional low ridges that retard surface drainage. Drainage is variable and is profoundly affected by seepage from adjacent areas.Internal drainage is retarted by a till substrate.	Low to Medium	84,557 % 2.38	Suited mainly for livestock production.Stoniness is the determining factor in land utilisation.Arable areas grow fair to poor crops of coarse grains.	Stoniness.Poor drainage. Low organic matter content of the soil. Susceptibility to wind erosion when cultivated.
Similar vegetation to that of the shallow phase.	Similar to the shallow phase.	Low to Medium.	78,080 % 2.20	More suited to livestock and dairying. A larger percentage of the soils may be cultivated in the deep phase as stoniness is not as severe as in the shallow phase.	Poor internal drainage. Low water retention and droughtiness of surface soil in dry seasons, but subject to a high water table and excess moisture in the profile in wet seasons. Wind erosion on exposed arable fields. Stoniness in most sections.

(Cont'd.)

TABLE NO. 6--SUMMARY OF THE SOIL CHARACTERISTICS, INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA (Cont'd.)

Soil Zone or Subzone	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture"
Grey-Black Transitional Zone	POPPLETON	Dominant Soil Associate (PHw) Intermediately drained "A_0" Horizon: Dark grey leaf and sod mat, ½ to 2 inches thick; neutral. "A_1" Horizon: Dark grey loamy fine sand, 2 to 6 inches thick; structureless; loose; neutral to slightly acid. "A_2" Horizon: Light grey to light brownish grey fine sand, 2 to 5 inches thick; structureless; loose; slightly acid. "B" Horizon: Pale brown to brown fine sand to fine sandy loam; 6 to 20 inches thick; loose to extremely friable; iron stained; slightly acid on the top and grading to slightly alkaline at the base. "Ca" Horizon: Light grey to pale yellow fine sand; 4 to 8 inches thick; structureless; loose; alkaline, effervesces moderately. "C" Horizon: Pale yellow to very pale brown fine sand; structureless; loose; calcareous and iron stained. "D" Horizon: Calcareous till at depths exceeding 30 inches.	Intermediately drained associates: Degrading Blackearth soils (P-PHw). Blackearth-like soils (P-PH). Blackearth-Meadow soils (PH). Poorly drained associates: Meadow soils (H). Meadow Podzols (Hd). Peaty Meadow soils (Ho).	Sandy deposits over till (encountered at a depth of 30 or more inches). Surface textures are dominantly loamy fine sand.
	TOLSTOI	Dominant Soil Associate (PHw) Intermediately drained "A_0" Horizon: Very dark grey leaf and sod mat; slightly alkaline. "A_1" Horizon: Dark grey to very dark grey sandy loam, 8 to 10 inches thick; structureless; extremely friable; slightly alkaline. "B" Horizon: Light grey fine sand 4 to 6 inches thick; structureless; weakly cemented; alkaline, effervesces slightly. "BC" Horizon: Gravelly and cobbly lens 5 to 8 inches thick; highly calcareous. "C" Horizon: Pale yellow sand to coarse sand; structureless; loose; strongly alkaline; stained with limonite. "D" Horizon: Calcareous till underlies the sandy mantle at 30 or more inches.	Intermediately drained associates: Degrading Blackearth soils (P-PHw). Blackearth-like soils (P-PH). Blackearth-Meadow soils (PH). Poorly drained associates: Meadow soils (H). Peaty Meadow soils (Ho).	More or less stony sandy deposits over till (encountered at a depth of 30 or more inches). One or more lenses of gravel or cobbles may be present in the outwash mantle. Surface textures range from loamy sand to sandy loam.
	LEARY	Dominant Soil Associate (Pw) Well-drained "A_0" Horizon: Brown sod and leaf mat, 1 to 1½ inches thick; neutral to slightly alkaline. "A_1" Horizon: Dark grey to very dark grey sandy loam to coarse loamy sand, ½ to 4 inches thick; structureless; loose; slightly alkaline. "A_2" Horizon: Greyish brown loamy sand to coarse sand, 1 to 4 inches thick; structureless; loose; slightly alkaline. "B" Horizon: Brown to yellowish brown, loamy sand to loamy fine gravel, 3 to 4 inches thick; structureless; loose; slightly alkaline. "C" Horizon: Pale brown to yellowish brown stratified coarse sand and gravel. The gravel is composed of well-rounded limestone and granitoid particles.	Well-drained associates: Blackearth soils (P). Intermediately drained associates: Degrading Blackearth-Meadow soils (PHw). Blackearth-Meadow soils (PH).	Stratified sand and gravel beach and glacio-fluvial deposits. Surface textures range from loamy coarse sand to sandy loam.
Grey Wooded Zone	SALTEL	Dominant Soil Associate (PH) Intermediately drained "A_0" Horizon: Very dark brown leaf mat 1 to 2 inches thick; neutral. "A_1" Horizon: Very thin or absent. "A_2" Horizon: Grey heavy clay loam to clay, 1 to 2 inches thick; granular sometimes feebly platy; hard; neutral to slightly acid. "B" Horizon: Very dark grey to dark brown clay, 4 to 6 inches thick; medium blocky; very hard; neutral. Grades sharply into:- "Ca" Horizon: Grey clay loam to heavy clay loam, 2 to 4 inches thick; granular; hard; calcareous. This is underlain with light grey water-worked coarse textured layers which frequently contain a lens composed of coarse fragments ranging from gravel to small cobbles. This layer is 1 to 12 inches thick and highly calcareous. "D" Horizon: Pale brown heavy sandy loam to clay loam till; calcareous; fragmental in structure.	Intermediately drained associates: Humid Grey-Black soils (PHw). Poorly drained associates: Peaty Meadow soils (Ho). Meadow Podzols (Hd).	Thin lacustrine deposits 6 to 15 inches (±) in depth over till. Surface textures range from heavy clay loam to clay.
	BROKENHEAD	Dominant Soil Associate (P-PH) Well to Intermediately drained "A_0" Horizon: Dark greyish brown leaf mat, 1 to 2 inches thick; slightly acid. "A_1" Horizon: Very dark grey clay loam to clay about 1 inch thick; granular; friable; slightly acid. "A_2" Horizon: Greyish brown sandy clay loam, 2 to 4 inches thick; feebly platy; friable; slightly acid. "B_2" Horizon: Dark greyish brown clay, 8 to 11 inches thick; medium blocky; very hard; neutral to slightly alkaline. "B_3" Horizon: Dark greyish brown clay, 9 to 12 inches thick; fine blocky to coarse granular; very hard; alkaline. Grades into:- "Ca" Horizon: Light brownish grey clay 8 to 10 inches thick; strongly alkaline. "C" Horizon: This horizon may be absent, or present as olive grey clay up to 10 inches thick; mottled, carbonated and iron stained. A lens of sand and gravel may occur at the junction of the clay and till. "D" Horizon: Pale brown, slightly laminated, calcareous, modified till.	Intermediately drained associates: Moist Grey-Black soils (P-PHw). Humid Grey-Black soils (PHw). Humid Grey Wooded soils (PH). Poorly drained associates: Peaty Meadow soils (Ho). Meadow Podzols (Hd).	Thin lacustrine or overwash material 16 to 30 inches (±) in depth over calcareous till. Surface textures range from heavy clay loam to clay.

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Dominantly deciduous woods, consisting mainly of aspen, black poplar and willow.	Smooth very gently sloping topography. Internal drainage is impeded due to a till substrate which causes ar aperiodic water table.	Low.	70,707 % 1.99	Dairying and livestock production. Limited suitability for coarse grains. Crop rotations should feature forage crop production to produce livestock feed and maintain soil productivity.	Wind erosion on cultivated fields. Low water-retention capacity, due to sandy texture, but this in part is offset by moist subsoil conditions during wet seasons.
Tall prairie grasses and herbs intermixed with woods of aspen and oak.	Smooth very gently sloping topography. Internal drainage is retarded to a till substrate and soils may have an aperiodic water table.	Low.	2,790 % .08	Mainly livestock production. Stoniness restricts cultivation. Grass-legume mixtures should be utilized predominantly in crop rotation on arable land.	Imperfect internal drainage. Stoniness is often severe. Low water-retention capacity. Low organic matter content. Wind erosion on cultivated fields.
Tall prairie grasses and herbs intermixed with scrubby poplar and oak.	Rounded ridges of varying width and heighth. Drainage generally good, internal drainage is excessive.	Low.	12,774 % .36	Submarginal for grain crops; may be used for grazing.	Low fertility. Wind erosion if exposed by cultivation. Low organic matter content. Low water-retention capacity.
Mixed woods consisting of aspen, black poplar, spruce and willow on the better-drained sites. Tamarack and spruce along with reeds and sedges in the poorly drained sites.	Level topography. Surface drainage ranges from imperfect to poor. Internal drainage is slow because of the clay textured surface material.	Medium.	4,096 % .12	Suitable for grain and mixed farming, if adequately drained.	Slow surface and internal drainage. Low organic matter content. Local stoniness.
Some coniferous woods intermixed with deciduous forest. Poorly drained sites are either forested by spruce and tamarack or covered by meadow grasses, sedges and reeds.	Level topography with slight micro-undulations. Surface drainage and internal drainage are slow because of the flat nature of the topography, and the clay texture of the soils.	Medium high.	2,842 % .08	Good for general agricultural crops.	Heavy tillage moderately low in organic matter. Slow surface and internal drainage. Local flood hazard.

(Cont'd)

TABLE NO. 6 — SUMMARY OF THE SOIL CHARACTERISTICS,
INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA. (Cont'd)

Soil Zone or Subzone	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture"
Grey • Wooded Zone	GARSON COMPLEX	A soil complex consisting of degrading Rendzina soils on reworked calcareous boulder till, and of minimal Grey Wooded soils developed on a mantle of sandy and stony erosion residue, up to 15 inches thick, resting on reworked calcareous till. All degrees of transition are present but stony soils with very thin or thin sandy mantle predominate.	Well-drained associates: Grey Wooded soils (P). Grey-Black soils (Pw). Intermediately drained associates: Humid Grey Wooded soils (PH). Humid Grey-Black soils (PHw) Poorly drained associates: Meadow Podzols (Hd). Peaty Meadow soils (Ho).	More or less stony, modified glacial till, with or without a thin layer of water-worked materials on the surface ranging up to 15 inches in thickness. Surface textures range from sandy loams to clay loams.
	CALIENTO	Dominant Soil Associate (PH) Intermediately drained "A_0" Horizon: Dark grey leaf and sod mat, 1 to 2 inches thick; neutral in reaction. "A_1" Horizon: Dark grey fine sandy loam,2 to 3 inches thick; structureless;extremely friable;neutral. "A_2" Horizon: Light grey fine sand,3 to 6 inches thick;structureless;loose;neutral to slightly acid. "B" Horizon: Olive yellow loamy sand to fine sand,6 to 10 inches thick;laminated;weakly cemented when dry;iron stained; neutral. "Ca" Horizon: Pale yellow weakly perceptible lime carbonate horizon;sandy loam in texture;very friable;usually containing a gravelly or cobbly lens 2 to 5 inches thick. "D" Horizon: Pale yellow to pale brown calcareous lake-washed till. This material is strongly laminated,fragmental in structure, and heavy sandy loam to sandy clay loam in texture.	Well-drained associates: Grey Wooded soils (P). Grey-Black soils(Pw). Intermediately drained associates: Humid Grey - Black soils (PHw). Poorly drained associates: Meadow Podzols (Hd). Peaty Meadow soils(Ho)	Sandy deposits 16 to 30 inches (±) in depth over calcareous lake-washed till. Surface textures range from fine sand to fine sandy loam.
	PINE RIDGE	Dominant Soil Associate (P) Well drained "A_0" Horizon: Brown leaf and sod mat,1 inch thick; neutral. "A_1" Horizon: Very thin or absent. "A_2" Horizon: Grey loamy fine sand to sand,5 to 8 inches thick; structureless;loose;neutral to slightly acid. "B" Horizon: Light brownish grey to light yellowish brown loamy sand to fine sandy loam, 7 to 20 inches thick;structureless;extremely friable;neutral.Slightly alkaline in the lower part of the horizon. "Ca" Horizon: Light grey to white calcareous fine sand,5 to 8 inches thick;weakly cemented when dry. A thin gravel or cobble lens may occur. "C" Horizon: Grey to pale yellow sand to fine sand;structureless;loose;calcareous. "D" Horizon: Pale yellow to pale brown calcareous till or stratified drift encountered at a depth of 30 inches or more.	Well-drained associates: Grey-Black soils (Pw). Intermediately drained associates: Humid Grey Wooded soils (PH). Humid Grey-Black soils (PHw). Poorly drained associates: Meadow Podzols (Hd). Peaty Meadow soils(Ho)	Sandy deposits 30 or more inches in depth over calcareous lake-washed till. Surface textures range from loamy fine sand to fine sandy loam.
	VITA	Dominant Soil Associate (P-PH) Well to Intermediately drained "Ao" Horizon: Very dark brown leaf and sod mat, ½ to 1½ inches thick; neutral. "A1" Horizon: Dark grey to greyish brown loamy sand to sandy loam, ½ to 2 inches thick; structureless; loose; neutral in reaction. "A2" Horizon: Light brownish grey to pale brown sand to fine sand, 3 to 7 inches thick; structureless; loose; neutral to slightly acid. "B" Horizon: Brown loamy fine sand to fine sandy loam, 5 to 8 inches thick; structureless to weakly granular; loose to extremely friable; sometimes weakly cemented when dry; neutral to slightly acid. "Ca" Horizon: White to pale brown sand, may be somewhat gravelly; 5 to 12 inches thick; highly calcareous. "C" Horizon: Light grey to pale brown sand; structureless; loose; highly calcareous. Gravelly and cobbly lenses of varying thickness occur in this horizon. "D" Horizon: Calcareous lake-washed till encountered at 30 or more inches in depth. (Sandy mantle may be up to 10 feet thick.)	Well-drained associates: Grey-Black soils(Pw). Intermediately drained associates: Humid Grey Wooded soils (PH). Humid Grey-Black soils (PHw) Poorly drained associates: Peaty Meadow soils (Ho).	More or less stony sandy deposits 30 or more inches in depth containing one or more lenses of gravel over lake-washed calcareous till. Surface textures range from loamy sand to sandy loam.
	BIRDS HILL	Dominant Soil Associate (P) Well-drained "Ao" Horizon: Brown sod and leaf mat, 1 to 1½ inches thick; neutral in reaction. "A_1" Horizon: Dark grey loamy sand to light sandy loam, 1 to 3 inches thick; structureless; loose; neutral to slightly alkaline. "A_2" Horizon: Light brownish grey loamy sand to sand, 2 to 4 inches thick; structureless; loose; neutral to slightly alkaline. "B" Horizon: Brown to yellowish brown coarse sand to light coarse sandy loam, (often with an admixture of gravel), 3 to 5 inches thick; usually loose but may be slightly cemented when dry; moderately alkaline. "C" Horizon: Pale brown to light yellow brown coarse sand and gravel; usually stratified; moderately alkaline. (May contain some cobbles.)	Well-drained associates: Grey-Black soils (Pw) Blackearth soils(O-P) Intermediately drained associates: Humid Grey Wooded soils (PH). Humid Grey-Black soils (PHw). Poorly drained associates: Peaty Meadow soils (Ho).	Beach and glacial outwash deposits. May be in the form of eskers, kames, osars or outwash plains. Surface textures range from loamy coarse sand to sandy loam.

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Deciduous woods consisting dominantly of aspen, with oak, black poplar and a few white spruce. Tamarack, black spruce, willow and swamp birch occur in the poorly drained sites.	Very gently to gently sloping topography with depressional areas of varying size that are imperfectly to poorly drained.	Low.	137,472 % 3.88	Land utilization influenced by degree of stoniness; the less stony or arable lands are fair for grain. Nonarable soils are used for pasture and farm woodlots. Fair to good crops of alfalfa for seed may be grown. This soil is best utilized for mixed farming.	Limited percentage of arable land due to stoniness. Lenses of gravel, cobbles, and broken stone often found at plough depth which interfere with both tillage and root development. High cost of clearing forest cover and stones. Shallow development of soil profile.
Scattered spruce interspersed with deciduous woods in the better-drained sites. Black spruce and tamarack, reeds and sedges in the wet sites.	Very gently sloping topography Drainage more or less imperfect. Large wet areas exist where run-off is slow and ponding occurs. Internal drainage retarded by the till substrate.	Low.	85,757 % 2.47	Suitable mainly for livestock production. Improvement crops are essential on arable land to reduce wind erosion hazard and to supply organic matter. Nonarable land used for pasture and woodlot.	Wind erosion of cultivated land. Low organic matter content and low water-retention capacity. Considerable stoniness where sandy mantle is thin.
Mainly aspen with some spruce and occasional jack pine, with an undergrowth of grasses and herbs on the better-drained sites. Tamarack, spruce, willow, reeds and sedges occur in the wet sites.	Level to gently sloping topography; may be slightly duned in places. Surface drainage is good, but internal drainage is impeded by the till substrate and a water table may be periodic.	Low.	91,162 % 2.57	Suitable only for livestock production and forestry. Submarginal for grains because of low fertility and coarse texture. Grasses and legumes should be the main crops grown on the arable land.	Wind erosion of cultivated land. Low water-retention capacity and droughty condition unless the soil is moistened by the shallow groundwater table. Low content of plant nutrients and organic matter.
Poplar and oak woods, and tall prairie grasses and herbs.	Level to very gently sloping topography. The level and basinal areas may be excessively wet because the till substrate arrests internal drainage. A shallow water table is common.	Low.	9,547 % .27	Chiefly used for livestock production. Fair for grasses and legumes, submarginal for grains because of low fertility. Nonarable land used for pasture and woodlot.	Wind erosion on cultivated fields. Local stoniness. Poor subsoil drainage. Low organic matter content and low water-retention capacity of surface soil.
Scattered clumps of aspen, oak, jack pine and ground cedar intermixed with small areas of upland grasses and herbs. Spruce, tamarack and meadow-grass vegetation on the poorly drained sites.	Variable sized ridges and mounds, sloping plains and irregular hillocks. Internal drainage is excessive but wet areas occur in depressions where the gravel is thin.	Very low.	29,235 % .82	Suitable only for limited grazing and the production of conifers. Some rye crops may be periodically grown on the finer textured plains and ridges.	Susceptible to wind erosion when exposed. Some areas are stony and cobbly. Soils are droughty and low in fertility.

(Cont'd)

TABLE NO. 6— SUMMARY OF THE SOIL CHARACTERISTICS,
INDICATED LAND USE AND SOIL PROBLEMS IN THE WINNIPEG-MORRIS AREA. (Cont'd.)

Local Soil Areas	Association	Profile Characteristics of Typical or Dominant Soil	Associated Local Soils	Geological "Parent Material and Prevailing Texture"
Sandy Podzol	MENISINO	Sandy podzolic soils in which the morphological characteristics are feebly developed and the soil horizons variable in depth. However the representative well-drained associate generally shows the following profile development:- A thin "A_1" horizon ½ to 1½ inches deep of light grey to light brownish grey loamy sand or sand which is structureless, loose, and slightly acid; and an "A_2" horizon of light grey sand or fine sand 4 to 6 or more inches in depth, that is structureless, loose, and acid in reaction. Below the "A" horizon there is an indefinite "B" horizon of variable depth, consisting of very pale brown sand or fine sand which is structureless, loose, and acid in reaction, and grades into a pale yellow sand which is structureless, loose, and neutral in reaction. Occasional stony areas may occur.	Intermediately drained soils in which the soil profile is shallower and more strongly developed.	Sandy deposits which are more or less siliceous and occasionally stony. Surface textures range from sand to fine sand.
Rendzina (High-lime)	ISAFOLD	Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Dark grey to very dark grey sandy loam to clay loam, 4 to 8 inches thick; fine granular; friable; alkaline, effervesces with acid. "AB" Horizon: Dark greyish brown loam to clay loam, 2 to 4 inches thick; medium granular; friable; alkaline. (Often a 4 to 7 inch lens of gravel may be found at the base or occluded as part of this horizon.) "Ca" Horizon: Light grey to white loam to clay loam, 5 to 8 inches thick; friable; marly. Fades into:- "C" Horizon: Light grey to pale brown till which is strongly calcareous and sometimes flecked with pink coloration from the parent limestone.	Wooded soils (Pw). Calcareous intermediately drained soils (PH_{Ca}). Poorly drained associates: Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Gs}). Peaty Meadow soils (Ho)	Highly calcareous till and modified till. Surface textures range from sandy loam to clay loam.
Alluvial Soils	RIVERDALE	Immature alluvial soils formed as the result of stream overflow along the Red and Assiniboine rivers and along their tributaries. The soil profile is composed of a leaf mat and layers of alluvial silty deposits of variable thickness which are fine sandy loam to silty clay in texture. The color is dominantly a light greyish brown in the upper portion but is slightly darker in the lower portion. The soil is friable and neutral to slightly alkaline throughout, and may be iron stained in the lower portion.		Alluvial deposits occur as river terraces and flood-plains. Surface textures range from fine sandy loam to silty clay.
	CARVILLE	An association of soils ranging from minimal to medial profile development. Dominant Soil Associate (P-PH) Well to Intermediately drained "A" Horizon: Dark grey clay to silty clay, 5 to 10 inches thick; weakly developed prismatic clods of irregular form break into fine granular aggregates; friable to hard; neutral to slightly alkaline "AC" Horizon: Dark greyish brown to greyish brown silty clay loam to clay, 6 to 10 inches thick; fine granular; slightly laminated; friable; contains some iron-staines and carbonate flecks. Grades into:- "C" Horizon: Light brownish grey silty clay to clay which is laminated; fine granular; friable; slightly iron stained and moderately calcareous. "D" Horizon: Lacustrine clay substratum at varying depths which is similar to the parent material of the Red River association.	Intermediately drained associates: Degrading Blackearth soils (P-PHw). Blackearth-Meadow soils (PH). Alkalinized soils (G). Salinized soils (Gs). Poorly drained associates: Meadow soils (H). Calcic Meadow soils (H_{Ca}). Saline Meadow soils (H_{Gs}) Peaty Meadow soils (Ho).	Alluvial silty and clay deposits. Surface textures range from silty clay loam to clay.
	ALLUVIUM	Undifferentiated alluvial deposits in the South-Eastern lake-terrace area which occur along streams which periodically overflow. This complex of soils which have no profile development range in texture from a fine sandy loam to a silty clay and are alkaline throughout.		Recent undifferentiated alluvium of variable texture.
Organic Soils	HALF-BOG	Organic deposits 10 to 30 inches (±) in depth made up of fen, woody or mixed peat. These deposits occur in the Grey-Black, Grey Wooded and in parts of the Blackearth soil zone.		Peat over mineral material.
	BOG	Organic deposits over 30 inches in depth made up of fen, woody or mixed peat. These deposits occur in the Grey-Black and Grey Wooded soil zones.		Peat.
Lakes				

Native Vegetation	Topography and Drainage	Natural Fertility	Acreage and % of Total Area	Suitability for Agricultural Use Indicated	Soil Problems
Dominantly jack pine on the well-drained sites, but big bluestem and upland grasses occur in open areas.Spruce and aspen intermixed with the jack pine on the imperfectly drained sites.	Irregular, gently sloping topography. Highly porous soil, hence water passes rapidly into and through the sandy deposits.	Very low.	14,669 % .41	Not suitable for arable culture. Best suited for coniferous forests.	Low water-retention capacity. Very low fertility.Wind erosion if the soil is exposed. Local stoniness.
Upland grasses and herbs interspersed with aspen,willow and occasionally oak on the better-drained sites. Meadow grasses, sedges and reeds on the poorly drained sites.	Very gently sloping, ridge and swale topography. The run-off from the ridges collects in the swales, causing varying degrees of hydromorphism. Internal drainage is slow.	Low.	31,386 % .89	Generally too stony for cultivation.Confined largely to livestock production. Forage is generally low in phosphate and deficiency of phosphate in cattle often results unless feed is supplemented with grain or the required mineral supplement.	Excessive stoniness. Imperfect drainage. High lime content. Low organic matter content.
Deciduous woods consisting of elm,ash,aspen, cottonwood,basswood,box-elder, black poplar and willow.	Uneven topography due to slight ridges and channels. Drainage generally is good except for flooding during spring break-up.	High.	44,442 % 1.25	Excellent for all regional crops, especially suitable for vegetable crops.	Periodic flooding during spring break-up. Requires organic matter if continuously cropped.
Poplar,oak,box-elder,elm,and tall prairie grasses and herbs on better-drained sites;meadow grasses,sedges and willows in more poorly drained sites.	Level with micro-relief. Drainage normally is good at the surface, but the subsoils may be moist. Impeded drainage in low sites and in soils with a clay substrate.	High.	25,499 % .72	Typical better-drained soils are excellent for all grain crops,corn,roots,grasses and legumes, and excellent for sugar beets. Halomorphic and meadow soils, when properly drained, are suitable for grain and hay production.	Poor subsoil drainage in local areas. Occasional spring flooding hazard from river overflow.
Mixed woods and meadow grasses.	River channels and terraces which are subject to flooding in periods of high water.	Highly fertile;subject to high seasonal water table.	10,726 % .30	Suitable for general agricultural crops in years without floods.Uncertainty of the water level in the soils restricts the land chiefly to grass,hay crops,grazing and forestry.	Flooding hazard.
Black spruce and tamarack,swale grasses,sedges, reeds,and moss.	Flat topography, generally excessively wet.	Very low.	51,891 % 1.46	Limited use for woodlots;fen peats can be used for grazing land or for hay production.	Excessive hydromorphism and low mineral content. Fire hazard when dry.
Poor stands of black spruce and tamarack;also sedges,moss and swale grasses.	Flat topography. More or less water-logged.	Very low.	97,357 % 2.74	Limited use for woodlot; some hay on fen peat areas.	Excessive hydromorphism and low mineral content. Fire hazard when dry.
			1,792 % .05	Wildlife.	Maintenance of water level in dry seasons.

TABLE NO. 7 : ESTIMATED SUITABILITY OF THE SOILS IN THE WINNIPEG-MORRIS AREA FOR VARIOUS PURPOSES.

Symbols: E = excellent; E-G = excellent to good; G-E = good to excellent; G = good; G-F = good to fair; F-G = fair to good; F = fair; F-P = fair to poor; P-F = poor to fair; P = poor; VP = very poor; V = variable; X = not naturally favorable, but could be utilized if suitable corrective measures were adopted; +– = more or less suitable; — = not suitable, or of relatively low value.

Note: The following estimates are given as a guide to the average suitability of each soil association for land use in average seasons. In seasons of above average precipitation, many of the soils will give better returns than are indicated, but in periods of severe drought, even the better soils may give less satisfactory returns. It should also be observed that the respective average estimates must be modified on local farms to conform with local variations. Further, the estimates given are not absolute values. They are the opinions of the soil surveyors based on the characteristics of the soil and on general observations.

	CULTIVATED LAND								UNBROKEN LAND			
	Grain Crops		Intertilled Crops			Cultivated Hay And Pasture Crops						
Soil Designation	Wheat	Coarse Grains	Fodder Corn	Seed Corn	Roots and Potatoes	Grasses	Legumes	Gardens And Fruits	Native Hay	Grazing	Wild Life	Forestry and Field Windbreaks
Agassiz Association	—	—	—	—	—	P	P	—	P	P-F	—	—
Alluvium	(X)F-G	(X)F-G	(X)G-F	?	(V)G	G	(X)F-G	G	G	G	+–	+
Altona Association:												
Fine sandy loams	G-F	G-F	G-E	G-E	G-E	F-G	G	G-E	F-G	F-G	—	++
Fine sandy clay loams	E-G	G-E	E	G-E	E	F-G	G	G-E	F-G	F-G	—	++
Birds Hill Association	—	—	—	—	—	P	P	—	P	P-F	+	+
Brokenhead Association	G	G	G-F	F-G	G-F	G	G-E	G-F	F	F	+–	++
Caliento Association	P-F	P-F	F-P	F-P	F	F	F-G	F	P-F	F	+	++
Emerson Association:												
Intermediately drained associate	G	G	G-E	G	G	G-F	G	G-F	G	G	—	+–
Wooded associate	G-E	G-E	G-E	G	G	G	G-E	G	G	G	—	++
Salinized associate	(X)F-G	(X)F-G	(X)F-G	?	(X) F	F-G	(V)F-G	(V) F	(V)F-G	F-G	—	—
Fort Garry Association	G	G	(V)G	(V)G-F	(V) G	G	G	(V) F-G	G	G	—	+–
Springbank Association	G	G	G-E	G-E	G-E	F-G	G	G-E	F-G	F-G	—	+
Carson Association	(V)F	(V)F	P-F	P-F	F	F-G	G-F	F	P	F	+	+
Horndean Complex:												
Intermediately drained associate	G	G	G-E	G	G-F	G-F	G	G-F	G	G	—	+–
Salinized associate	F-G	F-G	(V)G-F	(V)F-G	(X) F-G	F-G	G-F	(X) F-G	F-G	G-F	—	—
Isafold Association	(V)P-F	(V)F	P	P	(V) P-F	F-G	(V)F-G	(V) P-F	F	F-G	+–	—
Kittson Association:												
Shallow phase (6-15" sandy mantle)	(V)P-F	(V)P-F	(V)P-F	(V)P-F	F	F	F	F	F-G	F-G	+–	+
Deep phase (16-30" sandy mantle)	(V)F	(V)F	(V)F	(V)F	F-G	F-G	F-G	F-G	G-F	G-F	+–	+
Lakeland Association:												
Fine sandy loams	F-G	F-G	F-G	F-G	G-F	G-F	G	G-F	F-G	F-G	—	—
Clay loams to clays	G-F	G-F	F-G	F-G	F-G	G	G	F-G	F-G	F-G	—	—

Table No. 7 (cont.)

Soil Designation	CULTIVATED LAND								UNBROKEN LAND			
	Grain Crops		Intertilled Crops			Cultivated Hay And Pasture Crops						
	Wheat	Coarse Grains	Fodder Corn	Seed Corn	Roots and Potatoes	Grasses	Legumes	Gardens And Fruits	Native Hay	Grazing	Wild Life	Forestry and Field Windbreaks
Leary Association	—	—	—	—	—	P	P	—	—	—	—	+
Marquette Association:												
Intermediately drained associate	G-E	G-E	G	F-G	G-F	G	G	G-F	G-E	G-E	—	+
Salinized associate	(V)F-G	(V)F-G	(X)F	?	(X) F	F-G	(V)F-G	(X) F	G-F	G-F	—	—
Menisino Association	VP	VP	VP	VP	P	P-F	F-P	P	P	F-P	+	++
Oakville Association:												
Well to Intermediately drained associate	E	E-G	E	E-G	E	G-E	G-E	E-G	F	F	—	+
Poorly drained associate	(V)G	(V)G	(X)F	?	(X) F	F-G	(V)F-G	(X) F-G	G	G	—	+–
Peat	—	—	—	—	—	—	—	—	Extremely Variable			—
Peguis Association	G-E	G-E	G	G-F	G-F	G	G	G-F	F	F	+–	++
Pelan Association:												
Shallow phase (6-15" sandy mantle) ...	(V)P-F	(V)P-F	P	?	F	F	F	F	F-G	F-G	+–	++
Deep phase (16-30" sandy mantle)	(V)F	(V)F	F	F	F-G	F-G	F-G	F-G	G-F	G-F	+–	++
Pine Ridge Association	P	P	P-F	P-F	F-P	F	F-G	F-P	P-F	F	+	++
Poppleton Association	P	P-F	F	F	F	F	F-G	F	F-G	F-G	+–	++
Red River Association:												
Well to Intermediately drained associate	E-G	G-E	G-E	G	G-F	G	G-E	G-E	G	G	—	+
Intermediately drained associate	G-E	G	G	G-F	G-F	G	G	G	G-E	G-E	—	+
Poorly drained associate (Osborne) ...	(X)G-F	(X)G-F	(X)F	?	(X) F	G	(V)F-G	(X) F-G	G	G	—	—
Salinized associate	(X)F-G	(X)F-G	(X)F	?	(X) F	F-G	(V)F-G	(X) F	G-F	G-F	—	—
Solonetzic associate	G	G	(X)G	(X)G-F	F-G	G	G	G-F	G	G	—	+–
Wooded associate (St. Norbert)	G-E	G	G	G-F	G-F	G	G	G-E	G-E	F-G	+–	++
Red River - Emerson Transition	G-E	G	(V)G	(V)G	(V) G	G	(V)G	(V) G	G	G-F	—	+–
Riverdale Association	E-G	E-G	E	E	E	G	G	E	—	—	—	++
Saltel Association	F-G	F-G	F-G	?	G-F	G	G	G-F	F	F	+–	++
Semple Association	(V)F-G	(V)G-F	(V)F-G	?	F-G	(V)G-F	(V)G-F	F-G	F-G	F-G	—	++
Sperling Association	E-G	G-E	E-G	G-E	G-E	G	G-E	G-E	G	G	—	++
Steinbach Association	G	G	(V)G	(V)G	G-E	G-E	(V)G-E	G-E	G	G	—	+
Tolstoi Association	P	P-F	F	F	F	F	F-G	F	F-G	F-G	+–	++
Vita Association	P	P	P-F	P-F	F-P	F	F-G	F-G	P-F	F	+	++
Woodlands Complex	(V)F	(V)F	(V)F-P	?	(V) F	F-G	(V)G-F	(V) F	F-G	G-F	+–	—
Zora Association:												
Fine sandy loams	G-F	F-G	(V)G	?	G-F	G-E	G-E	G-F	F	F	+–	++
Loams to silty clays	G-E	G	G	?	G	G-E	G-E	G	F	F	+–	++

(2) LAND-USE CAPABILITY CLASSES:

The soils which occur on the Winnipeg-Morris map sheets can be grouped into land-use capability classes on the basis of observed characteristics such as soil depth and texture, slope, erosion, stoniness, salinity, drainage and fertility. Brief definitions of the eight recognized land-use capability classes, together with a list of the soils that may be placed in each class, are given under the following headings:-

(a) Land Suited to Arable Culture:

Class I -- Land of very good productivity. Highly productive soils on land that is level to very gently sloping. Some local areas may need clearing, provision for water control, and fertility maintenance. However, good farming methods are essential to keep the soil in good condition and to control weeds, diseases and insect pests. The following soils may be listed in this category:-

Riverdale soil association;
Sperling soil association;
Oakville, well to intermediately drained associates;
Red River, well to intermediately drained associate;
Altona soil association, (fine sandy clay loams).

Class II -- Land of good productivity. Good soils on land that is level to gently sloping. Some areas in certain soil associations may be slightly stony, some may require moderate drainage, and some areas may be subject to wind and water erosion or may require improvement in workability. The following soils may be listed in this category:-

Red River, intermediately drained associate;
Emerson, wooded associate;
Red River - Emerson transition;
Peguis soil association;
Marquette, intermediately drained associate;
Zora soil association, (loams to silty clays);
Emerson, well to intermediately drained associates;
Semple soil association;
Fort Garry soil association;
Red River, wooded associate, (St. Norbert clay);
Red River, "alkalinized" (or solonetzic) associate;
Brokenhead soil association;
Horndean soil complex (V)*;
Springbank soil association;
Steinbach soil association;
Altona soil association, (fine sandy loams);
Zora soil association, (fine sandy loams).

Class III -- Land of moderate productivity. Soils in this land class are limited in productivity due to one or more of a number of factors such as: susceptibility to wind and water erosion, limited fertility, soil drought (due to sandy texture or to physiological drought resulting from excess lime carbonate), salinity, stoniness, poor drainage, etc. These limitations may be of the same kind as those noted in Class II land, but the limiting factors are effective to a greater degree. The following soils may be listed in this category:-

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* The symbol (V) as here used implies variability and hence a range of land-use capability may be expected with the soils thus designated.

Lakeland soil association, (clay loams to clays);
Woodlands soil complex;
Alluvium (V);
Red River, poorly drained associate, (Osborne clay);
Saltel soil association;
Oakville, poorly drained associate;
Lakeland soil association, (fine sandy loams);
Kittson soil association, (deep phase);
Red River, salinized associate.

(b) Land Suited For Limited Arable Culture:

Class IV -- Land of limited productivity. Soils in this class are best suited for hay, pasture, or forestry, but may include local areas of somewhat better soils that can be used for crop production to a limited extent. Limitations of this class are, low fertility, unfavorable topography, stoniness, or arrested drainage. The following soils may be listed in this category:-

Pine Ridge, poorly drained associate;
Garson soil complex, (less stony areas);
Marquette, salinized associate;
Pelan soil association, (deep phase);
Caliento soil association;
Poppleton soil association;
Tolstoi soil association;
Vita soil association;
Isafold soil association;
Pine Ridge, well-drained associate.

(c) Land Not Generally Suited to Arable Culture:

Class V -- Land suitable chiefly for grazing, hay or forestry. The lands in this class are level to gently sloping and not particularly subject to erosion, but they are not suited for general crop production because the soils are either stony, salinized, calcareous, infertile, gravelly, coarse textured, or poorly drained. The following soils may be listed in this category:-

Kittson soil association, (shallow phase);
Pelan soil association, (shallow phase);
Garson soil complex (stony and gravelly areas);
Agassiz soil association;
Leary soil association;
Menisino soil association;
Birds Hill soil association;

Class VI -- Land suitable for hay, grazing or tree production with limitations. Land may be inaccessible for part of the summer season because of being wet or boggy. One group of soils only is here listed in this category:-

Bog (or peat) soils.

Class VII -- Land suited for grazing or forestry with major limitations. The land in this class requires extreme care to prevent erosion, destructive burning, or overgrazing. Such land may be steep, rough, hilly and highly susceptible to erosion. Generally this class is most suited for forestry. No soils of the Winnipeg-Morris area are listed in this land-use capability class.

Class VIII -- Land suited for wild life and recreation. This land may be extremely rough, rocky, or water-logged. No soils in the Winnipeg-Morris area are listed in this land-use capability class.

5. ANALYTICAL AND EXPERIMENTAL DATA:

Many of the soil management problems in the Blackearth and Grey - Black soil zone of the Winnipeg-Morris area centre around the physical features of the soils rather than around their initial fertility. Complete chemical analyses are not a general prerequisite to the solution of the major soil problems. However, certain physical and chemical determinations were made on representative samples of the major soils in order to obtain specific information of practical importance. The results of these determinations, together with comments on their significance, are presented under the headings of

(1) Surface Soils, and (2) Soil Profiles.

(1) SURFACE SOILS:

From the various soils mapped, a large number of surface samples were collected in the field. These samples were taken to a depth of six inches. Where possible, both virgin and cultivated samples were secured, but in many cases typical undisturbed samples were not obtainable. The water retention capacity, as indicated by the moisture equivalent values of these samples, was determined to provide a check on the textural names given to the soils. Representative samples were then selected from each group of samples and subjected to mechanical analysis, and a limited number of chemical determinations of agronomic interest were conducted on these samples. The laboratory determinations made include, mechanical analysis (to ascertain the texture); moisture equivalent values (from which the water retention capacity was calculated); total nitrogen, and so-called "available phosphate" and "available potash" (to give an indication of fertility); and pH values (to indicate reaction).

(a) Mechanical Analysis and Water Retention Capacity:

The mechanical analyses data of the representative surface samples are shown in Table No. 8; and the moisture capacity and indications of fertility of the representative soils are shown combined in Table No. 9. It should be explained that, in the method of mechanical analysis used, the soils were first treated with a dispersing reagent to break down the micro-aggregates so that the sand, silt and clay could be separated with more precision. The cementing materials brought into solution in this procedure are included in the "solution loss" figures in Table No. 8, but as the "solution loss" in some cases may include considerable soluble mineral material, the "solution loss" figures cannot be considered as a measure of the humified organic matter. However, where the "solution Loss" is low, the soluble organic matter is also low.

The water retention capacity of the soils was obtained by ascertaining the moisture equivalent values* and then calculating the inches of water retained against the pull of gravity, per six-inch depth, for each comparable set of soil samples. The water retention capacity**figures thus obtained are closely related to the amount of total clay and organic matter present. In connection with the indicated water retention capacity of the various soils, it should be noted that as the quantity of organic matter normally decreases with depth, the water retention capacity also correspondingly decreases with depth if the texture of the soil remains constant. (See charts of soil profile analyses, Figures 50 to 61.)

The figures in Table No. 9 indicate that the finest textured soils in the region are the Red River clay, Osborne clay, Marquette clay, Saltel clay, and the virgin Oakville silty clay to clay, all of which have an available water retention capacity above the hygroscopic coefficient of over two inches per six-inch depth of surface soil (or over 1½ inches above the wilting point). The St. Norbert clay, the cultivated Oakville silty clay to clay, the Riverdale silty

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* The "moisture equivalent" values represent the amount of water (in percent of dry soil) retained when wet soil is subjected to a definite constant centrifugal force. The retention capacity of soils for water thus obtained can be used to calculate the number of inches of water available to plants that the soil will retain under free drainage.

** The moisture equivalent is here taken as the upper limit of water retention by soils, but the lower limit to which plants can reduce the soil moisture is open to question. Two constants are recognized, i.e.; the wilting point, and the hygroscopic coefficient. Where plants are grown in pots or closed containers, the wilting point, or the moisture level at which plants wilt permanently, may be taken as the zero of available water. (For practical purposes this is calculated as moisture equivalent x .54 = calculated wilting point.) However, under field conditions in dry seasons, it is sometimes observed that soils may have moisture levels below the wilting point, despite the fact that the moisture between the wilting point and the hygroscopic coefficient is not easily absorbed by plants. However even when tap-rooted plants such as alfalfa continue to absorb moisture from the substrate, the roots in the upper levels cannot reduce soil moisture below the hygroscopic coefficient, and hence for purposes of camparison under field conditions, this point can be selected as the zero of available water. (This value can be calculated as moisture equivalent x .37 = calculated hygroscopic coefficient.) The available water capacity, expressed in inches, that can be retained by a given soil above the hygroscopic coefficient, can be converted to inches of available water that can be retained above the wilting point if they are multiplied by the factor .73. These calculated values are not absolute but they are sufficiently accurate for practical comparisons.

TABLE NO. 8 - MECHANICAL ANALYSES OF REPRESENTATIVE SURFACE SOIL SAMPLES. W

Number of Samples	Soils Mapped As	Condition: Virgin or Cultivated	Percentage of Mineral Soil Separates					
			SAND					
			Fine Gravel 2.0 to 1.0 mm	Coarse Sand 1.0 to 0.5 mm	Medium Sand 0.5 to .25 mm	Fine Sand .25 to .1 mm	Very Fine Sand .1 to .05 mm	Si .05 to mm
2	Red River clay	Cultivated	0.00	0.26	0.56	1.51	1.93	7.
1	Osborne clay	Cultivated	0.13	0.29	0.88	7.99	6.94	11.
2	Emerson silty clay	Cultivated	0.07	0.39	0.47	1.77	7.29	40.
1	Fort Garry clay	Cultivated	0.00	0.07	0.29	1.12	7.37	25.
3	Marquette clay	Cultivated	0.42	0.59	1.04	2.24	1.99	18.
3	Lakeland fine sandy loam	Cultivated	0.21	0.28	0.78	11.21	21.80	35.
7	Lakeland clay loam	Cultivated	0.03	0.20	0.50	4.39	10.03	31.
5	Altona fine sandy loam	Cultivated	0.11	0.38	0.91	6.05	57.75	13.
3	Altona clay loams	Cultivated	0.05	0.15	0.55	4.05	44.36	17.
2	Sperling heavy loam	Cultivated	0.00	0.08	0.45	5.88	44.81	12.
1	Sperling clay	Cultivated	0.00	0.12	0.15	6.47	13.62	21.
1	Oakville silty clay to clay	Cultivated	0.17	0.13	0.95	1.84	1.10	24.
4	Oakville silty clay to clay	Virgin	0.00	0.28	1.21	9.35	9.35	36.
2	Springbank fine sandy loam	Virgin	1.09	2.75	11.84	24.71	26.20	11.
2	Springbank fine sandy loam	Cultivated	0.56	0.99	2.60	24.81	38.67	6.
2	Steinbach fine sandy loam	Cultivated	0.67	1.04	1.90	14.49	44.76	6.
2	Kittson fine sandy loam (deep phase)	Virgin	0.85	1.48	8.28	39.68	16.83	7.
2	Kittson fine sandy loam (deep phase)	Cultivated	2.42	5.15	14.36	28.00	9.47	12.
2	Kittson fine sandy loam (shallow phase)	Virgin	1.41	4.17	12.91	33.84	10.60	18.
1	Agassiz loamy sand	Virgin	5.15	5.48	8.10	54.47	6.84	0.
1	Agassiz loamy sand	Cultivated	6.67	6.74	10.86	52.05	7.35	0.
3	Zora fine loams	Cultivated	0.05	0.30	0.68	5.31	25.82	21.
3	Semple clay loam to clay	Cultivated	1.96	2.78	4.88	13.65	7.87	19.
2	Peguis clay	Cultivated	0.57	0.80	1.17	1.47	1.76	20.
2	Pelan fine sandy loam (deep phase)	Virgin	2.38	2.95	12.06	45.10	4.07	3.
2	Pelan fine sandy loam (deep phase)	Cultivated	0.49	1.20	4.45	22.62	31.62	12.
1	Pelan fine sandy loam (shallow phase)	Virgin	1.30	3.81	16.49	42.00	4.06	2.
2	Tolstoi fine sandy loam	Virgin	0.98	2.42	8.44	43.47	10.51	4.
1	Tolstoi fine sandy loam	Cultivated	0.49	3.66	27.72	48.07	8.79	5.
3	Poppleton loamy fine sand	Virgin	1.32	3.29	8.33	52.72	13.18	3.
1	Pine Ridge fine sand to sand	Virgin	10.83	21.13	26.75	24.85	2.76	3.
4	Pine Ridge fine sand to sand	Cultivated	0.37	1.47	12.42	48.26	25.11	3.
3	Garson sandy loam	Cultivated	3.51	5.32	10.41	15.01	13.28	23.
2	Garson sandy loam	Virgin	3.38	5.55	11.94	31.86	7.86	9.
2	Leary loamy sand	Virgin	6.07	11.87	22.22	32.07	5.92	5.
1	Leary loamy sand	Cultivated	6.86	17.89	33.32	14.56	5.48	11.
2	Vita loamy sand	Virgin	4.96	13.19	29.23	28.04	4.36	0.
1	Brokenhead clay	Virgin	0.63	1.42	2.79	10.41	.14	15.
1	Brokenhead clay	Cultivated	0.35	0.89	1.83	7.85	.34	18.
2	Menisino fine sand	Virgin	0.62	1.97	8.86	57.46	.45	3.

ECHANICAL ANALYSES OF REPRESENTATIVE SURFACE SOIL SAMPLES. WINNIPEG-MORRIS AREA.

	Percentage of Mineral Soil Separates											
		SAND			SILT							
0	Coarse Sand 1.0 to 0.5 mm	Medium Sand 0.5 to .25 mm	Fine Sand .25 to .1 mm	Very Fine Sand .1 to .05 mm	Silt .05 to .005 mm	Fine Silt or Coarse Clay .005 to .002 mm	Clay Less Than .002 mm	Total Coarse Sand 2.0 to .25 mm	Total Fine Sand .25 to .05 mm	Total Silt .05 to .002 mm	Clay Less Than .002 mm	Soluble Organic and Mineral Matter as Solution Loss
	0.26	0.56	1.51	1.93	7.70	17.80	66.90	0.82	3.44	25.50	66.90	3.35
	0.29	0.88	7.99	6.94	11.40	16.40	52.40	1.30	14.93	27.80	52.40	3.28
	0.39	0.47	1.77	7.29	40.70	10.80	28.00	0.93	9.06	51.50	28.00	10.53
	0.07	0.29	1.12	7.37	25.00	11.10	49.00	0.36	8.49	36.10	49.00	6.05
	0.59	1.04	2.24	1.99	18.40	10.33	58.47	2.05	4.23	28.73	58.47	6.51
	0.28	0.78	11.21	21.80	35.67	7.07	15.13	1.27	33.01	42.74	15.13	7.85
	0.20	0.50	4.39	10.03	31.60	10.14	37.20	0.73	14.42	41.74	37.20	5.91
	0.38	0.91	6.05	57.75	13.94	3.30	13.98	1.40	63.80	16.24	13.98	4.58
	0.15	0.55	4.05	44.36	17.43	4.94	23.44	0.75	48.41	22.37	23.44	5.03
	0.08	0.45	5.88	44.81	12.92	4.94	26.33	0.53	50.69	17.86	26.33	4.59
	0.12	0.15	6.47	13.62	21.48	7.65	44.22	0.27	20.09	29.13	44.22	6.29
	0.13	0.95	1.84	1.10	24.31	14.88	52.60	1.25	2.94	39.19	52.60	4.01
	0.28	1.21	9.35	9.35	36.96	7.60	30.19	1.49	18.70	44.56	30.19	5.06
	2.75	11.84	24.71	26.20	11.70	7.30	3.70	15.67	50.91	19.00	3.70	10.73
	0.99	2.60	24.81	38.67	6.90	1.30	11.30	4.15	63.48	8.20	11.30	12.88
	1.04	1.90	14.49	44.76	6.20	2.20	16.90	3.60	59.25	8.40	16.90	11.86
	1.48	8.28	39.68	16.83	7.40	12.10	4.00	10.61	56.51	19.50	4.00	9.38
	5.15	14.36	28.00	9.47	12.40	4.20	18.80	21.92	37.46	16.60	18.80	5.22
	4.17	12.91	33.84	10.60	18.10	9.60	2.10	18.48	44.42	27.70	2.10	7.29
	5.48	8.10	54.47	6.84	0.60	4.00	4.40	18.73	61.31	4.60	4.40	10.96
	6.74	10.86	52.05	7.35	0.00	4.60	1.60	24.27	59.40	4.60	1.60	10.13
	0.30	0.68	5.31	25.82	21.00	6.93	30.26	1.03	31.13	28.13	30.26	9.65
	2.78	4.88	13.65	7.87	19.60	10.40	33.80	9.62	21.52	30.00	33.80	5.06
	0.80	1.17	1.47	1.76	20.30	8.80	59.70	2.54	3.22	29.10	59.70	5.44
	2.95	12.06	45.10	4.07	3.60	5.80	9.80	17.38	49.17	9.40	9.80	14.25
	1.20	4.45	22.62	31.62	12.60	3.10	19.30	6.13	54.24	15.70	19.30	4.63
	3.81	16.49	42.00	4.06	2.40	7.20	11.60	21.60	46.06	9.60	11.60	11.14
	2.42	8.44	43.47	10.51	4.90	6.70	12.60	11.83	53.98	11.60	12.60	9.99
	3.66	27.72	48.07	8.79	5.80	1.80	2.00	31.87	56.86	7.60	2.00	1.67
	3.29	8.33	52.72	18.18	3.07	6.53	3.53	12.94	70.90	9.60	3.53	3.03
	21.13	26.75	24.85	2.76	3.40	1.00	9.20	58.71	27.60	4.40	9.20	0.08
	1.47	12.42	48.26	25.11	3.85	1.60	4.50	14.26	73.38	5.45	4.50	2.41
	5.32	10.41	15.01	13.28	23.80	4.60	12.67	19.24	28.29	28.40	12.67	11.40
	5.55	11.94	31.86	7.86	9.50	4.50	15.80	20.87	39.71	14.00	15.80	9.63
	11.87	22.22	32.07	5.92	5.50	7.80	3.60	40.15	37.99	13.30	3.60	4.96
	17.89	33.32	14.56	5.18	11.00	2.00	6.40	58.07	20.04	13.00	6.40	2.49
	13.19	29.23	28.04	4.36	0.90	0.80	14.30	47.37	32.40	1.70	14.30	4.23
	1.42	2.79	10.41	6.14	15.00	8.60	49.80	4.84	16.55	23.60	49.80	5.21
	0.89	1.83	7.85	6.34	18.00	12.00	49.80	3.07	14.19	30.00	49.80	2.94
	1.97	8.86	57.46	22.15	3.90	0.50	2.80	11.45	79.91	4.40	2.80	1.45

TABLE NO. 9 - MOISTURE RETENTION CAPACITY AND INDICATIONS OF FERTILITY SHOWN BY REPRESENTATIVE SURFACE SOIL SAMPLES. WINNIPEG-MORRIS AREA.

Soils Mapped As	Condition:- Virgin=V Cultivated=C	Moisture Retention Capacity		Calculated Water Retention Capacity In Inches Per Six-Inch Depth		Indications of Fertility		So-Called "Readily Available"		
		No. of Samples	Moisture Equivalent (1)	Hygroscopic Coefficient	Wilting Point	No. of Samples	Percent Total Nitrogen (2)	Phosphate (3)	Potash (4)	Reaction (pH) (5)
Red River clay	V	18	47.85	2.03	1.48	18	.490	L	EH	7.37
Red River clay	C	17	46.63	1.98	1.45	17	.363	L	VH	7.40
St. Norbert clay	V	2	46.04	1.95	1.42	2	.398	L	VH	6.81
St. Norbert clay	C	2	43.37	1.84	1.34	2	.296	L	VH	7.36
Osborne clay	V	11	50.28	2.13	1.55	11	.418	L	H	7.80
Osborne clay	C	10	49.23	2.13	1.55	10	.339	L	H	7.84
Riverdale complex	V	1	40.17	1.82	1.33	1	.427	VL	EH	7.70
Riverdale complex	C	1	39.38	1.79	1.31	1	.344	VL	EH	7.90
Fort Garry clay	V	3	35.66	1.51	1.10	3	.381	VL	EH	7.81
Fort Garry clay	C	1	39.64	1.68	1.23	1	.390	VL	EH	8.15
Emerson silty clay	V	3	40.43	1.71	1.25	3	.525	M	MH	7.67
Emerson silty clay	C	3	41.28	1.75	1.28	3	.577	M	MH	7.57
Marquette clay	V	11	48.84	2.07	1.51	11	.466	L	H	7.51
Marquette clay	C	10	47.85	2.03	1.48	10	.386	L	MH	7.62
Lakeland fine sandy loam	V	5	34.04	1.96	1.43	5	.517	L	EH	7.87
Lakeland fine sandy loam	C	5	28.39	1.63	1.19	5	.375	L	MH	8.00
Lakeland clay loams	V	7	41.74	2.02	1.47	7	.546	L	EH	7.94
Lakeland clay loams	C	7	38.92	1.89	1.38	7	.490	L	EH	8.12
Altona fine sandy loam	V	3	19.01	1.09	0.79	3	.395	M	H	7.51
Altona fine sandy loam	C	13	15.86	0.91	0.65	1	.259	L-M	M-H	7.35
Altona clay loams	V	3	29.48	1.60	1.17	1	.506	M-H	H	7.45
Altona clay loams	C	16	22.06	1.20	0.87	3	.317	M	H	7.20
Sperling heavy loam	C	6	32.08	1.55	1.13	3	.358	M-H	M-H	7.12
Woodlands Complex	V	4	28.33	1.37	1.00	4	.468	L	VH	7.61
Woodlands complex	C	4	27.73	1.34	0.98	4	.336	VL	M	7.83
Oakville silty clay to clay	V	5	48.90	2.07	1.51	5	.578	M	EH	7.52
Oakville silty clay to clay	C	5	44.62	1.89	1.38	5	.490	L	H	7.60
Isafold clay loam	V	2	40.28	1.95	1.42	4	.653	L	H	7.88
Springbank fine sandy loam	V	4	17.88	1.03	0.75	4	.284	L	L-M	7.82
Springbank fine sandy loam	C	4	15.99	0.92	0.67	4	.243	L	L	7.92
Steinbach fine sandy loam	V	2	26.33	1.52	1.11	2	.412	L	L	8.05
Steinbach fine sandy loam	C	2	21.19	1.22	0.89	2	.229	L	L	8.00
Kittson fine sandy loam	V	6	22.63	1.30	0.95	6	.386	L	H	7.67
Kittson fine sandy loam	C	6	20.06	1.15	0.84	6	.298	M	MH	7.63
Agassiz loamy sand	V	2	15.78	0.96	0.70	2	.373	MH	—	7.72
Agassiz loamy sand	C	2	20.97	1.27	0.93	2	.393	MH	--	7.69
Zora fine loams	V	7	33.83	1.64	1.20	7	.397	M	MH	7.64
Zora fine loams	C	7	31.94	1.55	1.13	7	.400	L	M	7.77
Semple clay loam to clay	V	5	41.21	1.87	1.36	5	.558	L	MH	7.33
Semple clay loam to clay	C	5	38.33	1.74	1.27	5	.414	L	MH	7.36
Peguis clay	V	9	43.80	1.86	1.36	9	.544	L	VH	7.12
Peguis clay	C	9	38.26	1.62	1.18	9	.376	L	MH	7.42
Pelan fine sandy loam	V	7	22.36	1.29	0.94	7	.389	VL	M	7.56
Pelan fine sandy loam	C	7	23.37	1.34	0.98	7	.316	VL	H	7.62
Tolstoi fine sandy loam	V	3	17.13	0.99	0.72	3	.423	M	MH	7.13
Tolstoi fine sandy loam	C	3	17.29	0.99	0.72	3	.282	L	M	7.24
Saltel clay	V	1	48.98	2.08	1.52	1	.840	L	M	7.65
Poppleton loamy fine sand	V	3	11.33	0.65	0.47	3	.161	M	MH	7.42
Poppleton loamy fine sand	C	3	6.90	0.40	0.29	3	.104	M	L	7.50
Pine Ridge fine sand to sand	V	10	12.83	0.85	0.62	10	.199	L	L	7.09
Pine Ridge fine sand to sand	C	10	7.98	0.53	0.39	10	.116	L	L	7.32
Garson sandy loam	V	8	23.59	1.43	1.04	8	.319	M	MH	7.10
Garson sandy loam	C	4	25.81	1.56	1.10	4	.318	L	M	7.82
Leary loamy sand	V	4	17.05	1.03	0.75	4	.301	M	L	7.30
Leary loamy sand	C	3	11.04	0.67	0.49	3	.174	M	L	7.65
Vita loamy sand	V	2	13.15	0.80	0.58	2	.344	M	MH	7.30
Vita loamy sand	C	2	12.85	0.78	0.57	2	.217	MH	MH	7.72
Brokenhead clay	V	2	34.62	1.47	1.07	2	.369	M	VH	6.46
Brokenhead clay	C	2	31.21	1.32	0.96	2	.235	M	VH	6.57
Menisino fine sand	V	2	5.37	0.33	0.24	2	.049	VL	L	6.30

(1) Moisture equivalent by Briggs and McLane Method. (2) Total nitrogen by A.O.A.C. Gunning Method. (3) Readily "available phosphate" by Merkle Method. (4) Readily "available potash" by Merkle Method. (5) pH by glass electrode.

	Phosphorus (p.p.m.)	Potassium (p.p.m.)
Extra high (EH)	---	250+
Very high (VH)	100+	200-250
High (H)	50-100	150-200
Medium high (MH)	25-50	100-150
Medium (M)	12-25	75-100
Low (L)	5-12	0-75
Very low (VL)	0-5	---

clay, the Isafold clay loam, the Semple clay loam to clay, and Lakeland clay loam to clay soils have a retention capacity of 1 3/4 inches to 2 inches of water per six-inch depth of surface soil (or 1 1/4 to 1 1/2 inches above the wilting point). The Fort Garry, the Peguis, the Zora, and the Lakeland fine sandy loam soils have an available water retention capacity of 1 1/2 to 1 3/4 inches (or around 1 to 1 1/4 inches above the wilting point); the Emerson, the Sperling, the Steinbach and the Altona fine sandy clay loam soils have an available water retention capacity of 1 1/3 to 1 2/3 inches (or 1 to 1 1/4 inches above the wilting point); the Woodlands, the Kittson, the Pelan, the Garson, and the Brokenhead soils have a water retention capacity of 1 1/4 to 1 1/2 inches (or around 1 inch above the wilting point) These figures all refer to the water retention capacity of the soils to a plow depth of six inches.

The Altona fine sandy loams and the Springbank fine sandy loams have an available water retention capacity of 1 to 1 1/4 inches per six-inch depth of soil (or around 3/4 to 1 inch above the wilting point) The most droughty soils are the Tolstoi, the Poppleton, the Pine Ridge, the Menisino, the Vita, the Agassiz and the Leary soils which have an available water retention capacity of less than 1 inch per six-inch depth of soil (or less than 3/4 inch above the wilting point).

In most cases, where virgin soil samples were available for comparison with the cultivated soils, the available water retention capacity figures indicate that under cultivation, there is a reduction in water retention capacity due, in a large measure, to a reduction in clay content and in the amount of finely divided organic matter through the removal of these constituents by wind or water erosion.

From a soil class standpoint, the soils that present textural problems in this area are (a) the fine clays, including the Red River, Osborne, St. Norbert, Fort Garry, Marquette, Peguis, clays and the Horndean complex, etc., that are relatively heavy to till and are slow in drying; (b) the sandy textured soils, including the Altona, Kittson, Pelan, Springbank, Tolstoi, Poppleton, Pine Ridge, Vita, Caliento, and Menisino soils, etc., which are sandy, and more subject to drifting or erosion by wind; (c) the coarse textured soils, including the Agassiz, Leary and Birds Hill soils, etc., which have low water retention capacity and (in the well-drained positions) droughty subsoils; (d) the very stony soils such as the Garson, Isafold and Tolstoi soils, etc., that are often too stony to permit extensive arable culture; and (e) the soils with mixed textured profiles, including the Steinbach, shallow phase Kittson, Semple, Marquette, Pelan, Caliento, Vita, Woodlands, Fort Garry, Peguis and Saltel soils, etc., in which the internal drainage, and to some extent the soil-forming processes, are influenced by the differential layers of coarse and fine textures within the soil profile.

(b) Fertility:

In the Central Lowlands area, the natural fertility of the soils as a whole (as indicated by the total nitrogen, and the so-called "available potash") is generally good but, in many cases, the phosphate may be low. In the South-Eastern (lake-terrace) area, particularly in the forested portion, the soils are generally lower in nitrogen and phosphorus and in some cases potash, than in the Central Lowlands area, and low natural fertility is a major problem with some of these soils. In regard to the natural fertility of the soils as indicated in Table No. 9 by the total nitrogen, and by the so-called "available phosphate" and "available potash", the following points are worthy of note.

(i) Nitrogen:

The total nitrogen content is good to excellent for practically all the soils listed except for the sandy textured soils in the wooded regions, but it must be recognized that the availability of this element is affected by seasonal conditions. With few exceptions, the cultivated soils have a lower nitrogen content than the virgin soils. This may be seen readily by grouping the typical soils according to genetic soil types and textures as shown in Table No. 10.

(ii) Phosphate:

The ratings for "available phosphate" shown in Table No. 9 indicate that with few exceptions the soils of this area are medium to low in this plant nutrient.

(iii) Potash:

The indications are that the medium to clay textured soils of the Blackearth and of the Grey - Black transitional zones are high to very high in "available potash"; the sandy textured soils of the Blackearth and of the Grey - Black transitional zones, and the medium to heavy textured soils of the Grey wooded zone, are medium to high in "available potash"; the sandy textured soils of the Grey Wooded zone however tend to be low in this plant nutrient.

(iv) General:

The general conclusions that may be drawn from these analyses, in regard to the fertility conditions of the soils of the Winnipeg-Morris area, therefore are, that phosphorus is the element generally required; that nitrogen is relatively low in the sandy soils of the Grey - Black transitional and Grey Wooded zones; and that potash appears to be satisfactory, except in the sandy soils of the Grey Wooded zone with garden and root crops that require large amounts of this element.

Table No. 10: - Average Total Nitrogen in Comparable Virgin and Cultivated Soils (to six-inch depth) Arranged by Soil Textures Within Soil Zones In The Winnipeg-Morris Area.

Soil Zone And Texture	Average Per Cent Total Nitrogen In Virgin Soil	Cultivated Soil	Apparent Nitrogen Loss In Per Cent*
BLACKEARTH SOIL ZONE:			
Red River, Fort Garry and Marquette soils with clay surface texture	.426	.336	21.1
Emerson, Altona, Oakville and Lakeland soils with medium textured surface horizons	.551	.476	13.6
Springbank, Altona, Lakeland, Steinbach, Kittson and Agassiz soils with sandy surface texture	.385	.306	20.5
GREY - BLACK TRANSITIONAL ZONE:			
Semple and Peguis soils with clay surface texture	.549	.334	28.9
Zora soils with medium textured surface horizons	.397	.400	----
Pelan, Tolstoi, Poppleton and Leary soils with sandy surface texture	.334	.243	27.2
GREY WOODED SOIL ZONE:			
Brokenhead soils with clay surface texture	.369	.235	36.3
Garson soils with sandy or medium textured surface horizons	.319	.318	----
Pine Ridge and Vita soils with sandy surface textures	.223	.133	40.4

* Apparent nitrogen loss in per cent of the nitrogen level in the virgin soils.

(c) Field Experiments:

Additional evidence in respect of soil fertility is provided from fertilizer trials with wheat, conducted by the Soils Department of the University of Manitoba, during the years 1929 to 1931, on sixteen farms distributed throughout the Central Lowlands in the Winnipeg-Morris area. These trials were conducted before the soil survey was undertaken and hence, because a larger proportion of the trials were located on some soil types than on others, and because the number of trials on some types is very limited, the data do not justify comparisons between results secured on different soils. In general, the results of the fertilizer trials were similar throughout. The average results of all trials conducted on the sixteen farms in the three years are particularly noteworthy when compared with the soil analyses given in Table No. 9.

In these fertilizer trials ammonium sulphate was used as a carrier of nitrogen, triple-super phosphate was used as a carrier of phosphate, and potassium sulphate was used as a carrier of potash. These fertilizers, both singly and in combination, were applied in drills close to the seed of the wheat crops grown. The mean yields obtained for the three years from the respective treatments are given in Table No. 11.

Table No. 11: - Mean Yields of Wheat Obtained in Fertilizer Trials on Sixteen Farms in the Central Lowlands of Winnipeg-Morris Area, 1929 to 1931*.

Treatment	Mean Yield Per Acre (bus.)	Treatment	Mean Yield Per Acre (bus.)
No Fertilizer (C)	21.9	Phosphate (P)	25.6
Nitrogen (N)	24.0	Nitrogen & Phosphate (NP)	28.4
Potash (K)	21.8	Phosphate & Potash (PK)	25.0
Nitrogen & Potash (NK)	22.8	Nitrogen, Phosphate & Potash (NPK)	27.7

* Co-operative Fertilizer Trials, conducted by Soils Department, University of Manitoba, in co-operation with Manitoba Wheat Pool and Junior Seed Growers.

The results from the eight fertilizer treatments on the sixteen farms may be grouped for comparison of response to nitrogen, phosphate, and potash as follows:

(i) All plots receiving nitrogen alone or in combination versus all plots receiving no nitrogen.

(ii) All plots receiving phosphate alone or in combination versus all plots receiving no phosphate.

(iii) All plots receiving potash alone or in combination
versus all plots receiving no potash.

Table No. 12:- Response to Nitrogen, Phosphate and Potash Indicated by the Mean Yield of all Wheat Plots, With or Without the Respective Fertilizer Elements. Central Lowlands of Winnipeg-Morris Area, 1929 to 1931.

Number Of Plots In each Treatment	Treatment	Mean Yield In Bushels Per Acre	Treatment	Mean Yield In Bushels Per Acre	Indications
88	Without Nitrogen	23.6	With Nitrogen	25.5	8.05% increase
88	Without Phosphate	22.5	With Phosphate	26.6	13.7% increase
88	Without Potash	24.8	With Potash	24.2	No response

In these trials (see Table No. 12) the greatest increase was obtained with phosphate, the response to nitrogen was smaller but still significant, and there was no response to potash. While it may be contended that wheat is not the best indicator crop, nevertheless wheat is the major crop grown in the Central Lowlands. The general increase in yield from the application of phosphate throughout is significant, but it may be observed that the response to fertilizers in this area is affected profoundly by moisture and temperature. In dry seasons low levels of moisture may inhibit or slow up the growth of crops. Hence sufficient moisture must be available to provide for the additional growth induced when fertilizer is used. It should be noted also that although the total nitrogen in the Blackearth and Grey - Black soils is generally high, the availability of the nitrogen and phosphate in the soil organic matter is determined by the activity of micro-organisms, which in turn is affected by the temperature and moisture within the soil. Hence in spring seasons when the soil temperatures are low, (and especially when seeding after incorporating crop residues with a wide carbon-nitrogen ratio) a temporary deficiency of available nitrogen and phosphate can be expected. Hence additional amounts of nitrogen along with phosphate, are often required to ensure vigorous and balanced growth in the early stages of crop development.

The analyses of the soils in the Central Lowlands indicated a medium to high level of nitrogen, a low to medium level of "available phosphate" and a high level of "available potash". These analytical results are in line with the results obtained from the fertilizer trials where a marked response was obtained from applications of phosphate, a smaller but significant response from nitrogen, and no response from potash. Somewhat different results from those presented above may have been obtained had some of these fertilizer trials been conducted in the forested zone of the South-Eastern (lake-terrace) area. It might be expected that greater response to applications of nitrogen and potash would be obtained on the sandy soils in the Grey Wooded zone where the soil analyses indicated a lower level of these elements. Although experimental evidence in this regard is lacking in the case of cereal grains, field trials in recent years with sugar beets in the Steinbach area, and hay crops in the La Broquerie area, have indicated that significant response to potash as well as nitrogen and phosphate can be expected on the Grey Wooded soils of the eastern forested area.

(d) Soil Reaction:

From the standpoint of soil reaction, the values given in Table No.9 indicate that none of the well-drained soils listed are strongly acid. The reaction of most of the soils is slightly above the neutral point (pH 7 = neutral point) and some soils are decidedly alkaline in reaction due to their high lime content. Although some of the soils in the Grey Wooded zone show slight acidity, none of the well-drained soils listed are sufficiently acid to require the application of lime. This is due to the large amount of calcium carbonate generally present in the deposits on which the soils are formed. It should be noted, however, that the soils listed in Table No. 9 represent the typical or better-drained soils. They do not include the various locally humid and salinized associates which are much more limited in acreage.

(2) REPRESENTATIVE PROFILES:

To obtain data, which would supplement the field observations and throw additional light on the regional soil-forming processes, typical virgin soil profiles were selected and subjected to a limited number of analytical determinations. The data thus obtained are shown in graphic form in Figures No. 50 to No. 61.

For practical purposes the data presented in the graphic charts provide sufficient evidence to justify the classification of the soils in the Winnipeg-Morris area of Manitoba into three soil zones. These zones are (1) the Blackearth soil zone, (2) the Grey - Black soil zone, and (3) the Grey Wooded soil zone. Due to the high lime content of the soil parent material, and the poor drainage conditions under which some of them were formed, many of the soils in this area do not exhibit the normal characteristics of the zone in which they are placed.

The characteristics of the Altona clay loam, shown as Figure No. 50, indicate that this soil is a typical well-drained Blackearth. The graphs show that this soil has an accumulation of organic matter in the "A" horizon that is neutral in reaction, and it has an accumulation of calcium carbonate immediately below the organic accumulation. These morphological characteristics are zonal and have developed as the result of the action of the regional climate. The characteristics of the Red River clay, Figure No. 51; of the Marquette clay, Figure No. 52; and of the Fort Garry clay, Figure No. 53; indicate that these soils are examples of moderately to intermediately drained blackearth-like soils that have developed on different textured profiles. The Red River profile is clay textured throughout; the Marquette clay has a till subsoil and substrate; and the Fort Garry clay has a sandy clay to silty clay calcareous subsoil over varve clay substrate. The modifying effect of the texture and lime content of the respective soil materials, and the effect of the differential soil textures on internal drainage in the Marquette and Fort Garry clays, are apparent in the data shown in the respective figures. The characteristics of the Lakeland very fine sandy loam, shown as Figure No. 54, indicate that this soil is a moderately well-drained calcic Blackearth. This soil has a higher content of calcium carbonate than is normal for the region. It has an alkaline reaction and contains free calcium carbonate in the "A" or surface horizon, and it has a very high level of calcium carbonate in the subsoil and substrate. The high lime content in this case is the result of the mineralogical composition of the parent material, and of an impervious substrate that arrests internal drainage and tends to keep the subsoil in a moist condition.

The characteristics of the Semple clay, shown in Figure No. 55; and of the Peguis clay, shown as Figure No. 56; indicate that these soils are moderately well-drained degrading Blackearth or Grey - Black soils. In the Semple soil, early invasion by woods is shown by the highly organic leaf and sod mat present at the surface, and by the lower pH and lime content of the "A_1" horizon, but in this case degradation is only slight. In the Peguis soil, which has less lime reserve, degradation has proceeded somewhat farther than in the Semple soil. The characteristics of the Zora very fine sandy loam, shown as Figure No. 57, indicate that this soil is an example of an imperfectly drained calcic blackearth-like soil, with a moist subsoil, that is fairly common in the Grey - Black zone where a till substrate retards downward movement of water. Although located in the Grey - Black or degrading Blackearth soil zone, the Zora soil shows free calcium carbonate and an alkaline reaction in the dark colored "A" horizon. Thus it is a local rather than a regional soil. The characteristics of the Pelan sandy loam, shown as Figure No. 58, indicate that this soil is fairly typical of an imperfectly drained Grey - Black, or degrading Blackearth, developed on a sandy mantle over till.

The characteristics of the Brokenhead clay, shown as Figure No. 59, indicate that this soil is a fairly typical example of a moderately well-drained Grey Wooded soil. The data show that lime is leaching from the upper part of the profile, and accumulating in the lower portion; and also that calcium is being carried from the subsoil through plant roots to the leaves, which in turn are deposited on the surface, where the calcium is liberated as the leaves are decomposed and mineralized. The Garson fine sandy loam, shown as Figure No. 60, is located geographically in the Grey Wooded soil zone, and although the soil data show that degradation processes are regionally active, the soil parent material is so high in lime that it is highly resistant to the regional soil-forming processes. Hence, the Garson soil is a rendzina-like soil which shows only minimal development of Grey Wooded characteristics.

The characteristics of the Menisino fine sand, shown as Figure No. 61, indicate that this is a sandy podzolic soil, developed on reworked sandy outwash. This soil has a low content of organic matter, it is leached and acid in reaction, but because of its coarse texture and low clay content, it does not show a marked illuvial horizon.

6. AGRICULTURE AND LAND USE:

The earliest form of land utilization recorded during historic times in this area, may be classed as natural land use under a wild life regime, dominated by red men of the Saulteaux, Cree, Assiniboine and Sioux tribes.*

The discovery of Hudson Bay and James Bay by Henry Hudson in 1610, and the subsequent events that led to the issue of a charter to "The Governor and

* Bryce, G., "The Romantic Settlement of Lord Selkirk's Colonists", Musson Book Company, Toronto, 1909.

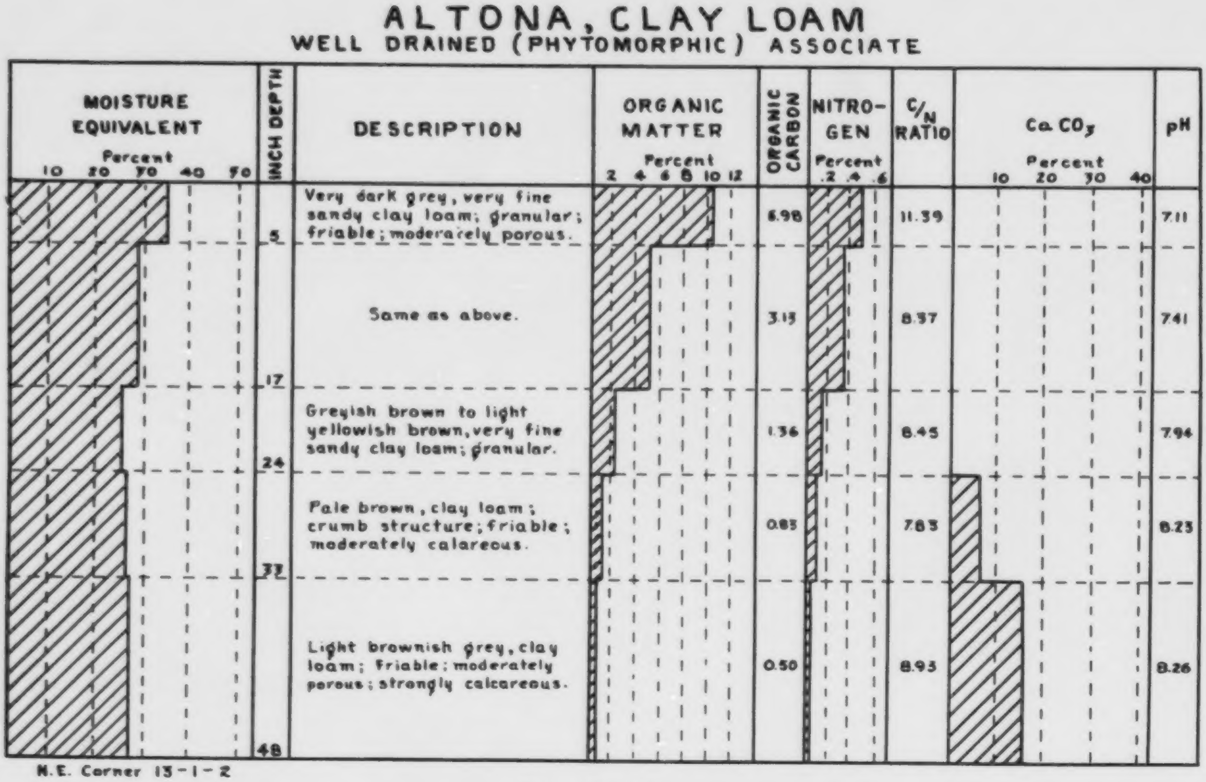


Figure No. 50
Typical Blackearth soil developed on lacustrine sediments, occurring as the well-drained member of the Altona soil association.

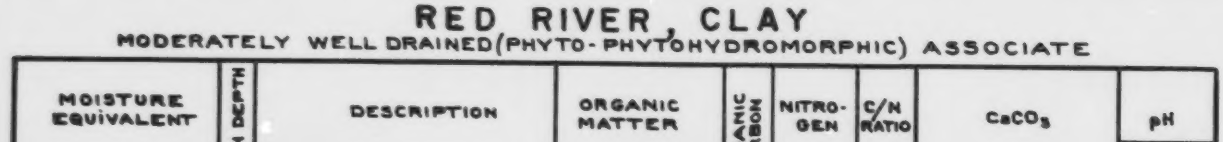
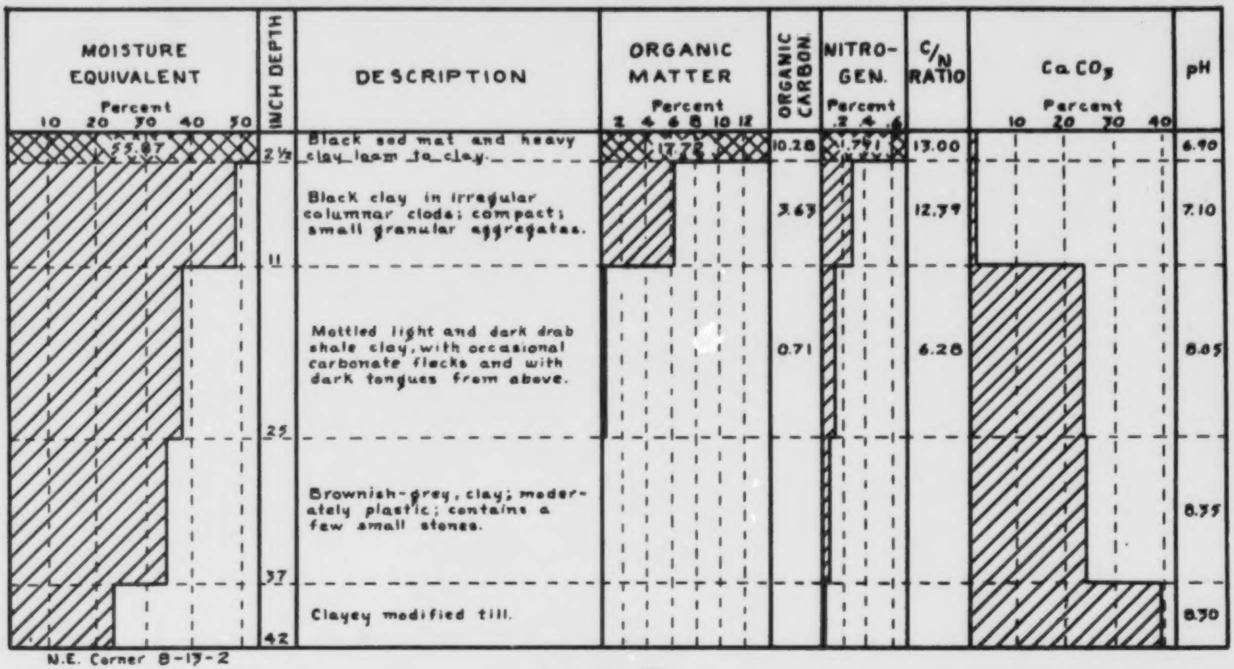


Figure No. 51
Moderately well-drained blackearth-like soil developed on lacustrine clay, occurring as the better-drained member of the Red River soil association.

MARQUETTE, CLAY

MODERATELY WELL DRAINED (PHYTO- PHYTOHYDROMORPHIC) ASSOCIATE

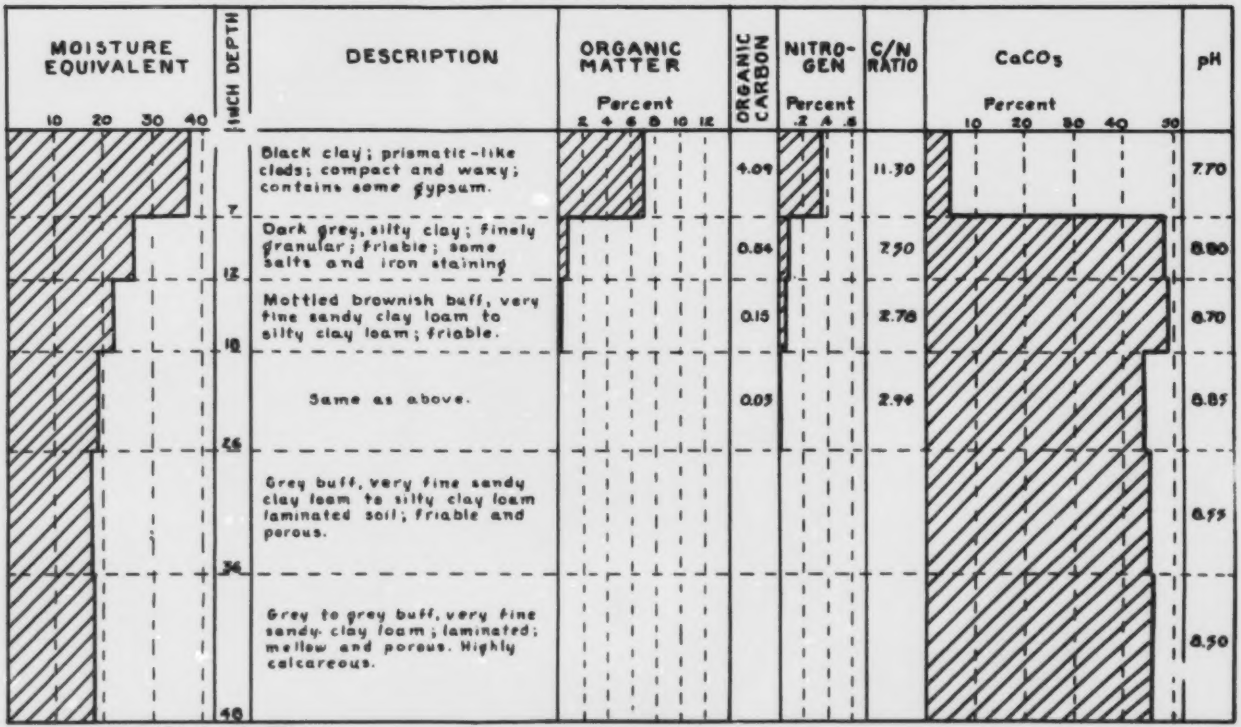


N.E. Corner 8-13-2

Figure No. 52
Moderately well-drained blackearth-like soil developed on a thin clay mantle of lacustrine clay over till, occurring as the better-drained member of the Marquette soil association.

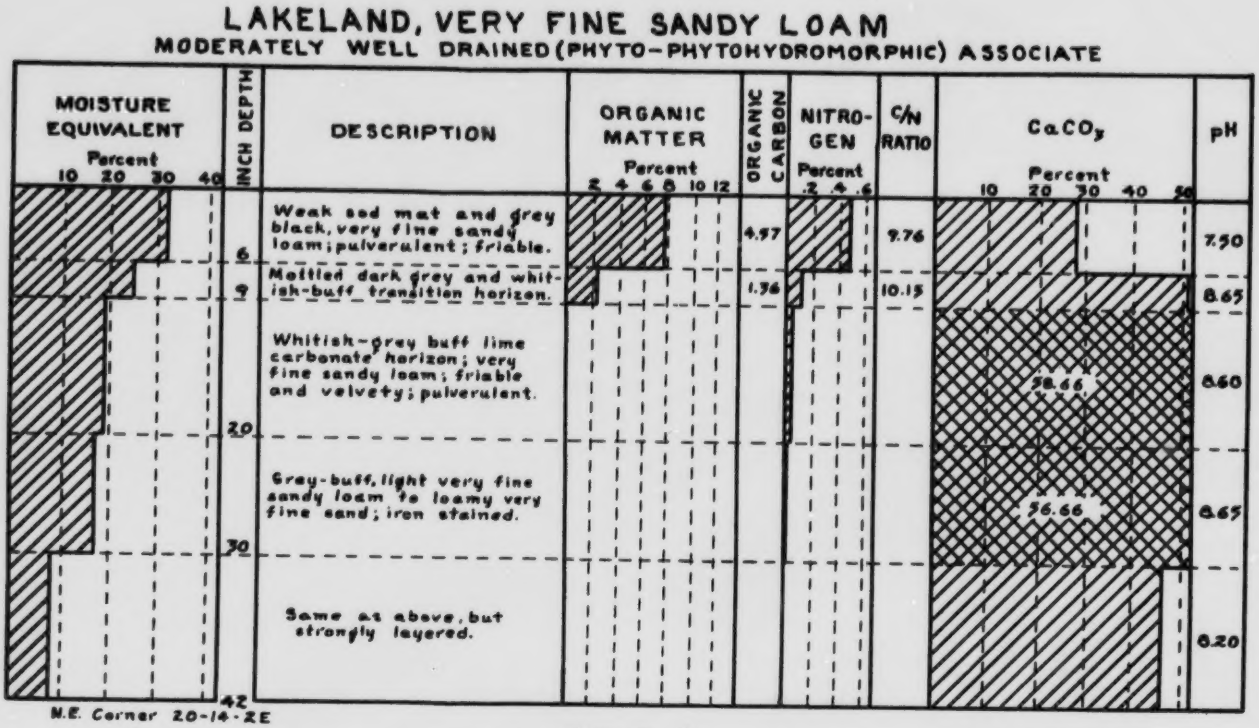
FORT GARRY, CLAY

INTERMEDIATELY DRAINED (PHYTO-HYDROMORPHIC) ASSOCIATE



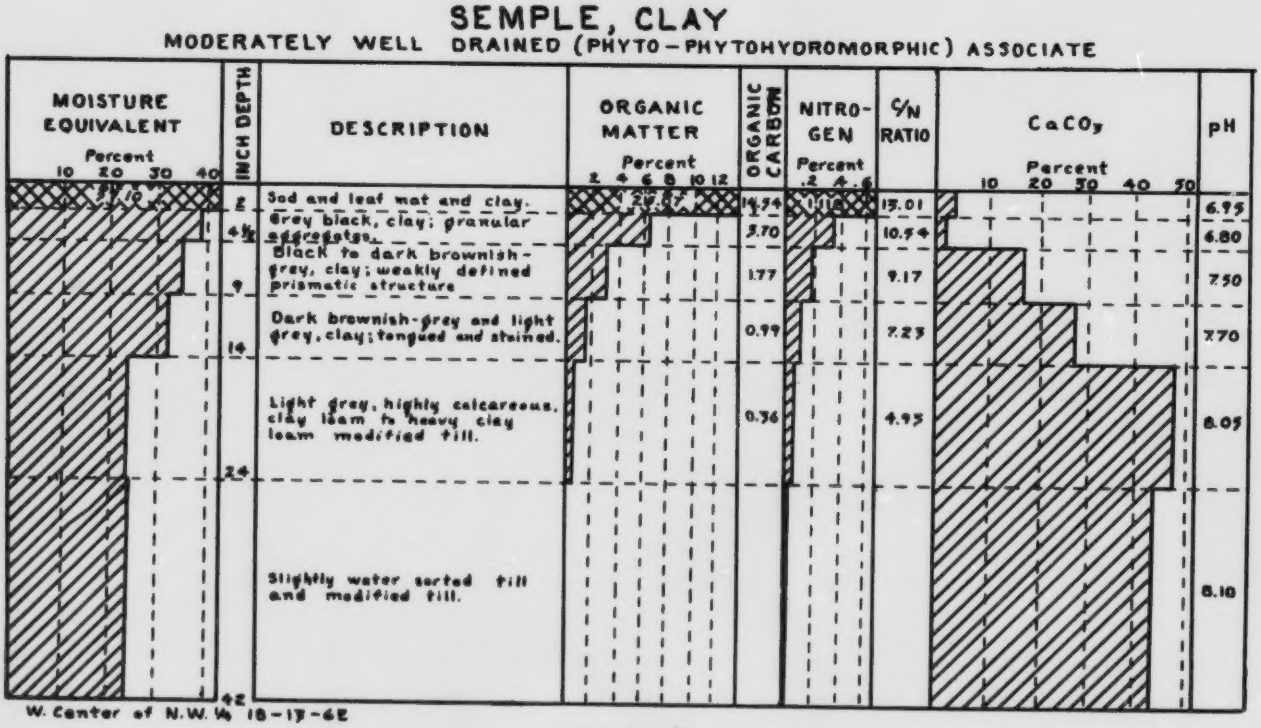
Kenaston Blvd. 10-2E

Figure No. 53
Meadow - Prairie or blackearth-like soil developed on clay over calcareous silty and fine sandy clay outwash, occurring as the intermediately drained member of the Fort Garry soil association.



N.E. Corner 20-14-2E

Figure No. 54
Moderately well-drained calcic Blackearth developed on medium textured sediments, occurring as the better-drained member of the Lakeland soil association.

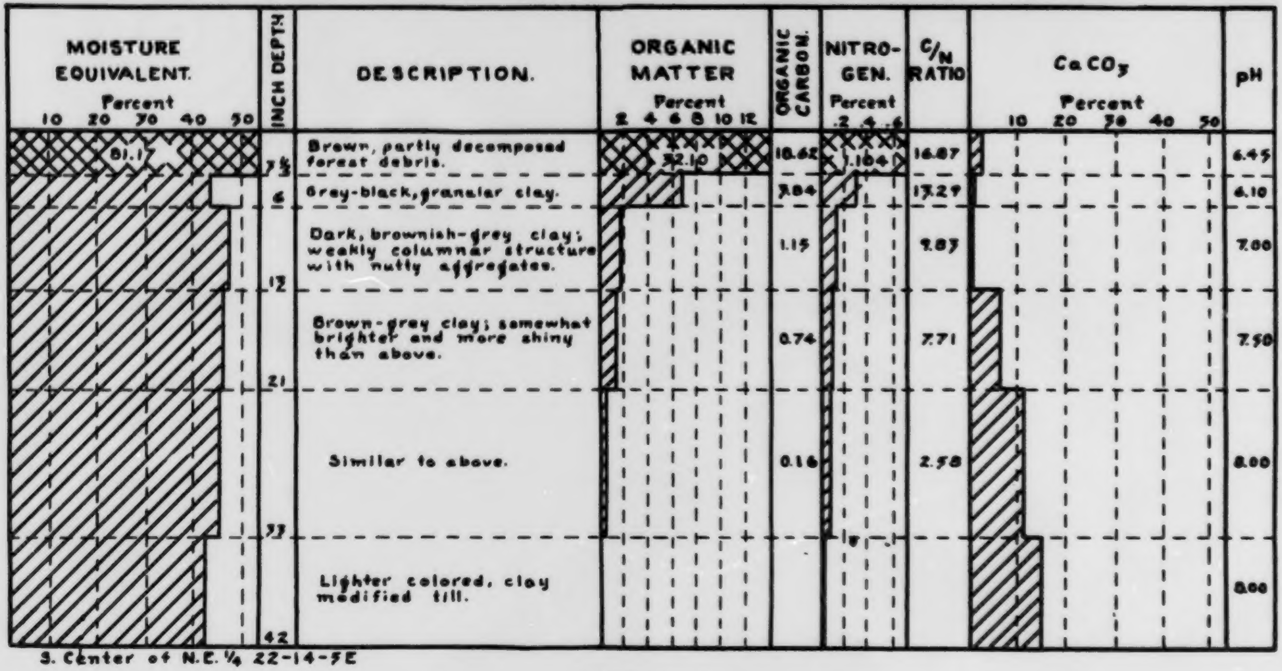


W. Center of N.W. ¼ 18-17-6E

Figure No. 55
Degrading Blackearth developed on a thin clay mantle on calcareous till, occurring as the moderately well-drained member of the Semple soil association.

PEGIUS, CLAY

MODERATELY WELL DRAINED (PHYTO-PHYTOHYDROMORPHIC) ASSOCIATE

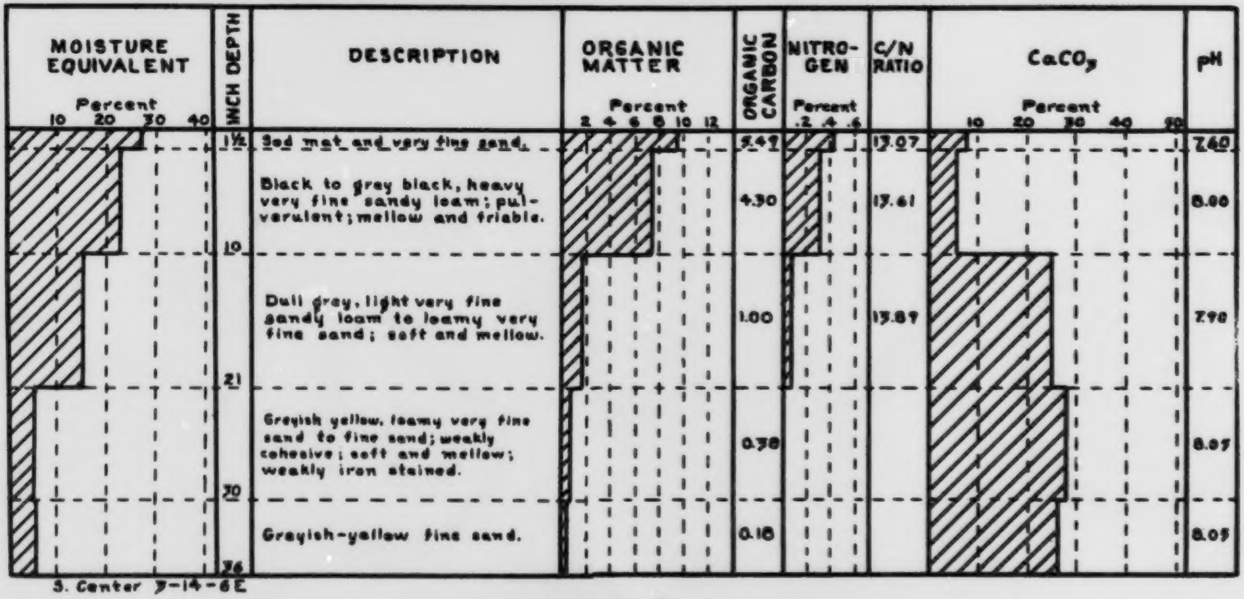


MOISTURE EQUIVALENT. Percent	INCH DEPTH	DESCRIPTION.	ORGANIC MATTER Percent	ORGANIC CARBON.	NITROGEN. Percent	C/N RATIO	pH
81.17	3	Brown, partly decomposed forest debris.	32.10	10.62	1.104	16.87	6.45
	6	Grey-black, granular clay.		7.84		13.29	6.10
	12	Dark, brownish-grey clay; weakly columnar structure with nutty aggregates.		1.15		9.87	7.00
	21	Brown-grey clay; somewhat brighter and more shiny than above.		0.74		7.71	7.50
	33	Similar to above.		0.16		2.58	8.00
	42	Lighter colored, clay modified till.					8.00

Figure No. 56
Degrading Blackearth or Grey - Black soil developed on clay over till substrate, occurring as the moderately well-drained member of the Peguis soil association.

ZORA, VERY FINE SANDY LOAM

IMPERFECTLY DRAINED (PHYTO-HYDROMORPHIC) ASSOCIATE



INCH DEPTH	DESCRIPTION	ORGANIC CARBON	C/N RATIO	pH
1½	Sod mat and very fine sand.	5.49	13.07	7.60
10	Black to grey black, heavy very fine sandy loam; pulverulent; mellow and friable.	4.30	13.61	8.00
21	Dull grey, light very fine sandy loam to loamy very fine sand; soft and mellow.	1.00	13.89	7.90
30	Greyish yellow, loamy very fine sand to fine sand; weakly cohesive; soft and mellow; weakly iron stained.	0.38		8.05
36	Greyish-yellow fine sand.	0.18		8.05

Figure No. 57
Calcic blackearth-like soil with moist subsoil developed on sandy sediments, occurring as the imperfectly drained and dominant member of the Zora soil association.

PELAN, SANDY LOAM
IMPERFECTLY DRAINED (PHYTO-HYDROMORPHIC) ASSOCIATE
SHALLOW PHASE

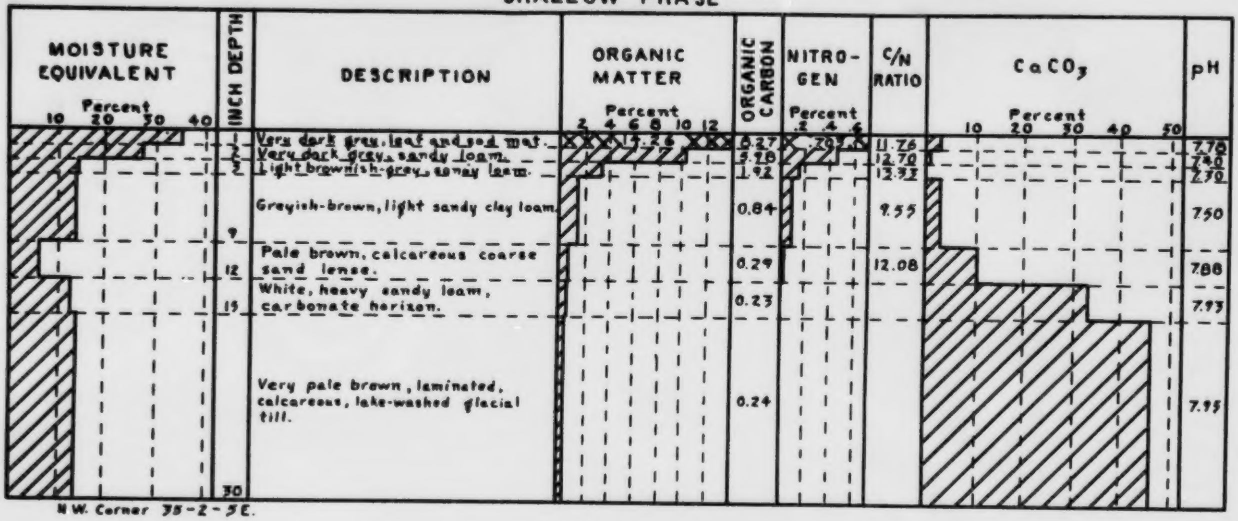


Figure No. 58

Degraded Blackearth or Grey - Black soil developed on a more or less sandy mantle over calcareous till, occurring as the imperfectly drained member of the Pelan soil association.

BROKENHEAD, CLAY
MODERATELY WELL DRAINED (PHYTO - PHYTOHYDROMORPHIC) ASSOCIATE

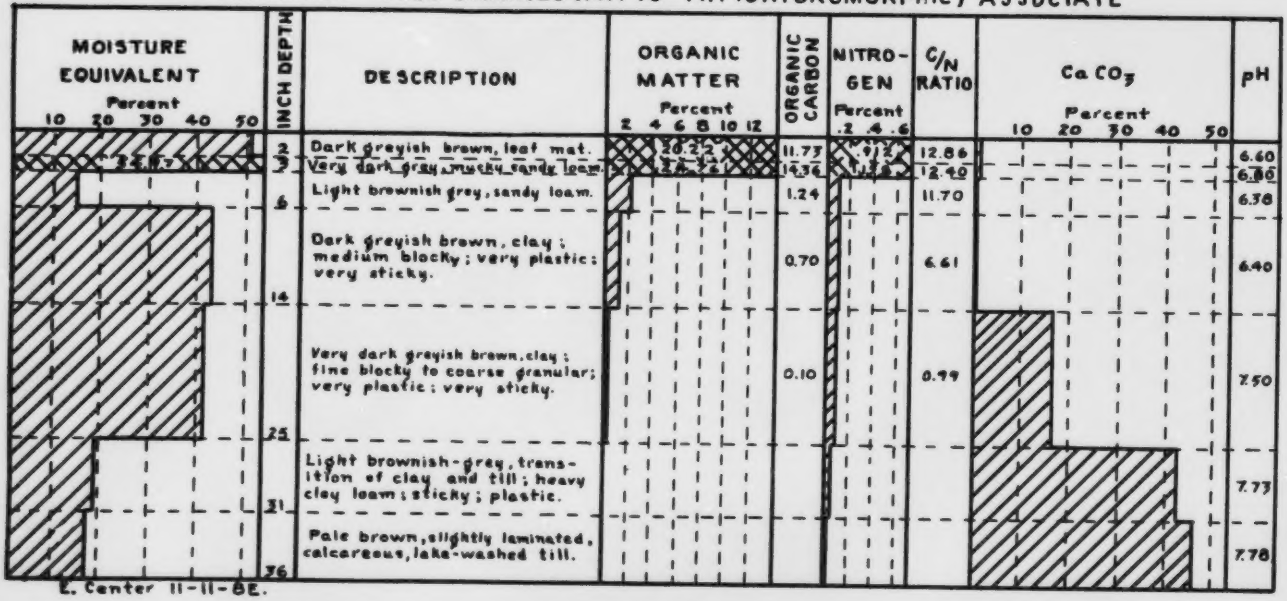
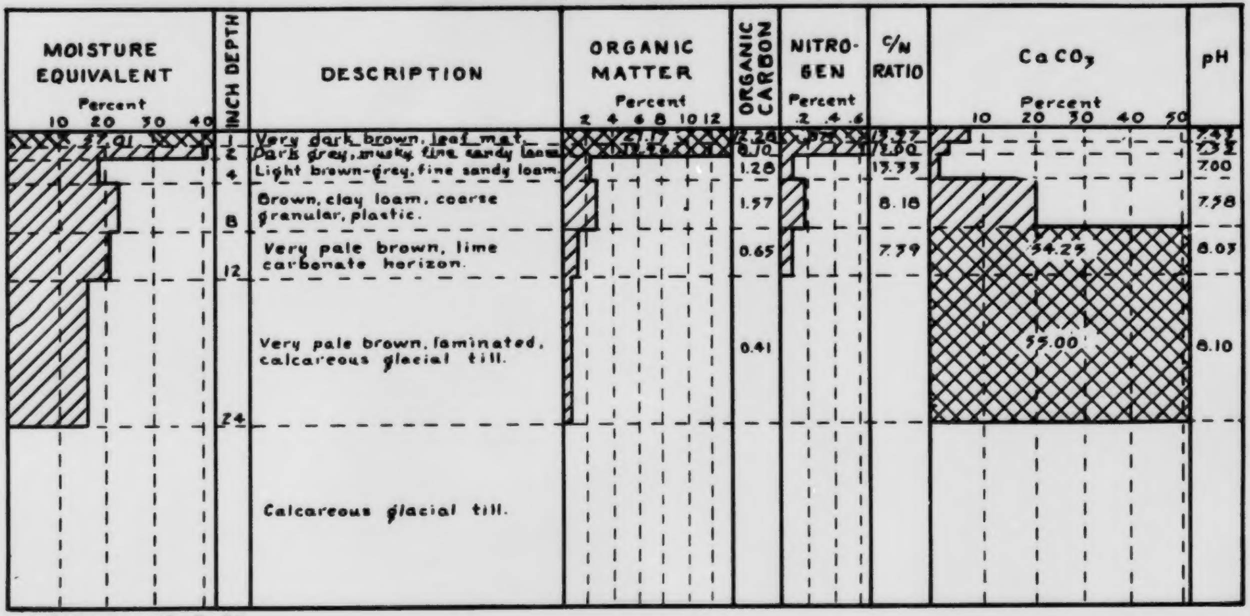


Figure No. 59

Grey Wooded soil developed on fine textured sediments over till substrate, occurring as the moderately well-drained associate of the Brokenhead soil association.

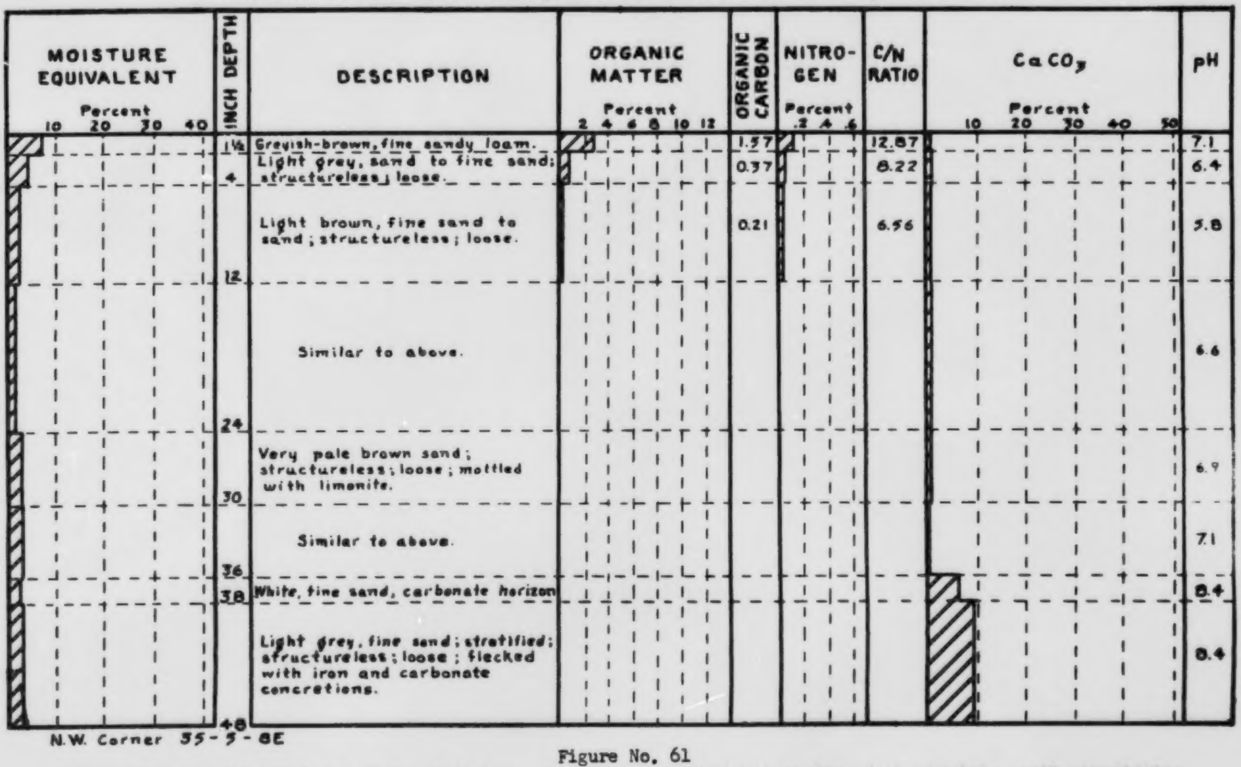
GARSON, FINE SANDY LOAM
WELL DRAINED (PHYTOMORPHIC) ASSOCIATE



S. Center 19-8-8E.

Figure No. 60
Degrading Rendzina soil developed on calcareous till with a shallow sandy mantle, occurring as the well-drained associate of the Garson soil association.

MENISINO, FINE SAND
IMPERFECTLY DRAINED (PHYTO-HYDROMORPHIC) ASSOCIATE



N.W. Corner 35-5-8E

Figure No. 61
Sandy podzolic soil developed under jack pine, occurring as a dominant member of the Menisino soil association.

Company of Adventurers of England trading into Hudson's Bay" in 1670, mark the commencement of an invasion by white men, and the initiation of the fur trade regime. Forts and trading posts were first established in the northern portion of what is now the Province of Manitoba, but as the years advanced, the fur trade extended southward. Following the western explorations of La Verendrye, and subsequent to 1731, forts and trading posts were built by rival fur companies on sites now occupied by the City of Winnipeg. Here, until 1812, the land remained virgin and the various forms of wild life that were produced naturally in the Red River region were exploited for the support of the white traders, the native red men, and the half-breed population. During the fur trade regime, under rival companies directed from London and Montreal, exploration and fur trading were the chief concern of the white men who first came into what is now known as the Red River plain, and no serious attempt at agricultural settlement appears to have been made until 1812. In that year a group of Scottish and Irish laborers and colonists, sponsored and financed by Thomas Douglas, Earl of Selkirk, and who had entered the country in 1811 via Hudson Bay, journeyed to the junction of the Red and Assiniboine rivers. These were the forerunners of the immigrants that became known as the Selkirk Colonists. These pioneers, and the other newcomers in subsequent years, together with fur trade employees who left their companies to settle on the land, established a very limited subsistence type of agriculture, along the Red and Assiniboine rivers, that was maintained for about sixty years.

The system of surveying and dividing the land along the Red River and its tributaries into river lots under this regime may be of interest. On July 18, 1817, a treaty was made by Lord Selkirk with the Indians at the forks of the Red and Assiniboine rivers. The Indians' version of the treaty was that they gave the Silver Chief, as they named Lord Selkirk, the land back from the river banks as far as daylight could be seen under the body of a pony standing on the level prairie*. These strips of land were subdivided into river lots (which are still a local feature) and the lots were grouped into parishes many of which bear the names of French and Scottish saints. The parish names are present-day evidence of the part played by the French speaking as well as the English speaking settlers in the early development of this area.

The type of land use practised in the Selkirk or Red River settlement is indicated by the census of 1831, which records that (after about 20 years of this mode of life) the population consisted of 2,390 persons, whereas the land under cultivation was only 2,152 acres. There were 410 horses, 958 oxen, 1,194 cows, 801 calves, and 362 swine. Twenty-five years later, the census of 1856 records a population of 6,691 and a cultivated acreage of 8,806. The figures show that, at both dates, the cultivated acreage was in the neighborhood of one acre per person, and hence the land use followed within the Red River settlement must have been a very simple form of subsistence agriculture, in which the settlers lived off the virgin as well as the cultivated land, while the fur trade continued to dominate the country as a whole. This elementary type of land use, as well as the domination of the fur trade, came to a close in the Red River region about the time the last brigade of Red River carts set out for Minnesota in the fall of 1871, and with the beginning of active agricultural land settlement on the prairies, which took place in the years immediately following the inauguration of the Province of Manitoba in 1870. When the province was formed, the system of land survey undertaken by the Dominion was a quadrilateral system in which townships of 6 by 6 miles or 36 square miles were subdivided into 36 sections of 640 acres or one square mile, and each section again divided into four quarter sections of 160 acres. This system was recommended by Colonel Dennis, who had the direction of the survey, and was approved by Order-in-Council, April 18, 1871. Consequently, as shown on the soil maps, all land in the Winnipeg-Morris area, except that initially subdivided into river lots during the Red River settlement regime. was surveyed and subdivided under the quadrilateral system.

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* Healy, W. J., "Women of Red River", Russell lang and Company, 1923.

The subdivision of the land on the prairies into legal parcels that could be acquired, and the discovery that the prairies were suitable for the production of wheat that could be exported, resulted in the development of these lands for a grain-growing type of agriculture. Begg* records that the first wheat shipped from Western Canada consisted of 857 bushels consigned by Higgins and Young to Steele & Bros. of Toronto on October 21, 1876. Hind** reports that this was Red Fife wheat which left the settlement by Red River steamer and was used for seed in Ontario. The price per bushel to the growers was 85 cents and the freight to Toronto was 35 cents. The names of the men who supplied this grain are recorded as:

G. R. Miller..................	Kildonan	204	Bushels
John McIvor	Greenwood	17 3/4	"
J. W. Carleton	Clear Springs	80 1/6	"
H. Soar	St. Johns	154	"
Neil McLeod	Victoria	22	"
F. Dick......................	Springfield	35	"
Robt. Black	Springfield	102	"
D. Donald	Springfield	94	"
John Spear	Springfield	44	"
Alex Gibson	Springfield	33	"
F. B. Robinson	Rockwood	32	"
John Reich	St. Paul	40	"

According to Hind, "the first shipment of wheat ..... direct to Britain was made in 1877" but "there were no further shipments for some years, because the rapidly-growing population consumed all that was grown, and in addition many tons of flour were brought in from the United States by the railway from the south which reached Winnipeg from St. Paul (Minnesota) in 1878". Following the discovery that the grasslands were suitable for grain growing on an extensive scale, agricultural expansion on the better-drained areas of the Central Lowlands was rapid, but on the extensive meadow areas of the Tobacco Creek and Boyne marshes it was retarded or slowed down until such time as these lands were reclaimed by systematic and coordinated drainage installations.

Among the first of the early settlers to settle on the prairie away from the wooded banks of the rivers, were a group of Mennonites from Russia who were allocated two large tracts of land in 1875 in the Altona-Winkler and the Steinbach districts. These settlers and their descendants have made valuable contributions to the development of agriculture in the Red River plain.

The area west of the Red River and north of the Altona-Winkler districts

*Begg, A., & Nursey, W.R., "Ten Years In Winnipeg", Page 138, Times Printing and Publishing House, Winnipeg, 1879.

**Hind, E.C., "A Story Of Wheat", Can. Geo. Jour., Vol. 11, Feb. 1931.

was first taken up by people chiefly of Anglo-Saxon origin, many of whom migrated from United States. However, on the east side of the Red River, settlers of Canadian French origin spread out from the river-lot holdings to occupy much of the eastern portion of the lowland plain. Settlement on the larger portion of the area that lies east of the Red River Plain made little progress until the first decade of the present century when people largely of Slavic origin moved into the wooded lands of the South-Eastern (lake-terrace) area. To these inferior lands under forest cover, these people brought many of the customs and practices of their European prototypes. The most recently developed lands to be brought under cultivation are the reclaimed meadow and poorly drained soils in the northeastern portion of the area, and the stony calcareous soils of the Woodlands-Stonewall sub-area. Here, due to the limited areas of new land available elsewhere for agricultural development, and to the high prices of agricultural products that prevailed following the World War of 1939 to 1945, the demand for land increased. The strong demand for land by land-seekers from older districts in Manitoba and Saskatchewan, coupled with the introduction of power machines for land clearing and reclamation, resulted in the settlement of the lands that had been passed by in former periods. Thus, the Winnipeg-Morris area, which also contains the cities of Winnipeg and St. Boniface, has a farm population of mixed origin, that is rich in the inheritance of varied cultural and racial backgrounds. Consequently, in this area, land use has been influenced to a marked degree by the attitudes and the cultural and racial backgrounds of the land operators as well as by natural features and economic conditions.

(1) AREA AND PRESENT USE OF FARM LANDS:

The area and present use that is now being made of the land in the Winnipeg-Morris area are reflected in the official figures contained in the Census of Canada and in the Provincial Crop Reports. The number of farms, the acreage held as farms, and the farm land in percent of total municipal acreage, according to census data for 1941 and 1946, are shown in Table No. 13. In this table the data are arranged in three groups. The land in the municipalities listed as Group 1, lies wholly or in large part within the Central Lowland area (see Figure No. 1, and 4). Here the land is practically all used as farms. The land in the municipalities listed as Group 2 is also in the Central Lowland area but, due to its proximity to the cities of Winnipeg and St. Boniface, the expanding urban and suburban use of land is here reducing and modifying the farm acreage. The land in the municipalities listed as Group 3 has not been used so extensively for agriculture in the past, as have the lands of the Red River Plain. On the one hand, the area of farm land within the municipalities of Ste. Anne, La Broquerie and Stuartburn has been restricted by problem soils and forest cover, but on the other hand, the farm acreage is now expanding in the Municipalities of Woodlands, Rockwood and St. Clements as the result of the reclamation of problem soil areas and of more favorable economic conditions.

The condition or present use of the farm land is shown in Table No. 14, and in the same groupings as in Table No. 13. The data in Table No. 14 show that the municipalities located in the open plains region of the Central Lowlands have a high percentage of the farm lands under cultivation, but that the municipalities located to the north and east of the Central Lowlands, (which have a lower percent of land held as farms), have a lower percent of farm land under cultivation. The noncultivated farm land, (which is recorded in the census reports as native pasture, woodland, marsh and waste land), may consist of runways and ravines; stony, gravelly, coarse textured, swampy or alkali soils; wet depressions; and unbroken bush land. These unbroken lands may be used to some extent as pasture or as woodlots, and some native hay is obtained from the poorly drained or meadow sites.

Table No. 13:- Number of Farms and Area of Farm Lands by Groups of Municipalities in Winnipeg-Morris Area. Census of Canada 1941 and 1946.

Municipalities	Number of Farms		Acreage Held as Farms		Farm Land In Percent of Total Acreage	
	1941	1946	1941	1946	1941	1946
Group 1:						
St. Andrews	1,026	907	146,926	155,425	81.02	85.71
Brokenhead	960	926	150,271	160,095	84.00	89.49
St. Francois Xavier..	113	113	45,589	45,955	93.04	93.79
Cartier	270	282	130,003	134,359	98.68	-----
Rosser	312	305	103,763	104,650	95.69	96.50
Springfield	1,451	1,237	205,978	199,080	78.30	75.68
Roland	362	355	114,927	115,085	99.76	99.90
Macdonald	679	669	268,532	268,911	97.68	97.82
Morris	757	784	252,009	243,097	-----	98.44
Richot	351	368	78,239	78,169	93.92	93.84
Tache	609	595	116,328	120,875	83.81	87.09
Hanover	1,088	1,113	166,614	171,360	90.95	93.54
De Salaberry	552	554	143,489	148,700	90.19	93.46
Rhineland	1,249	1,221	228,852	224,466	99.33	97.42
Montcalm	395	408	110,647	112,524	98.79	-----
Franklin	760	735	214,676	216,103	93.91	94.53
	10,934	10,572	2,476,843	2,498,854	92.27	93.09
Group 2:						
St. James	47	23	1,774	2,047	34.71	40.05
East St. Paul	157	165	7,991	6,482	79.82	64.75
West St. Paul	107	91	16,700	15,434	80.06	73.99
Old Kildonan	81	71	5,280	3,856	88.00	64.27
North Kildonan	178	108	4,331	2,664	73.08	44.95
East Kildonan	14	10	140	91	6.76	4.39
West Kildonan	34	13	136	73	7.18	3.85
St. Vital	242	210	16,737	16,090	-----	-----
Fort Garry	161	115	15,769	12,251	91.69	71.24
Assiniboia	146	73	19,516	15,701	91.00	73.20
Charleswood	164	171	20,240	18,597	86.18	79.18
	1,331	1,050	108,614	93,286	84.55	72.62
Group 3:						
Woodlands	448	416	141,810	170,329	52.67	63.26
Rockwood	978	919	204,838	215,544	69.58	73.22
St. Clements	1,150	1,196	113,159	130,401	57.77	66.57
Ste. Anne	475	440	76,958	72,769	67,69	64.00
La Broquerie	234	191	106,811	74,950	77.26	54.22
Stuartburn*	793	650	150,363	136,476	54,37	49.35
	4,078	3,812	793,939	800,469	61.64	62.15

* Local Government District.

Table No. 14:- Condition of Farm Lands by Municipalities in Winnipeg-Morris Area. Census of Canada 1946

Municipalities	Cultivated Land (Percent)	Native Pasture (Percent)	Woodland (Percent)	Marsh and Waste Land (Percent)
Group 1:				
St. Andrews	58.34	35.61	5.08	0.97
Brokenhead	64.91	24.94	6.08	4.07
St.Francois Xavier	74.30	13.11	10.70	1.89
Cartier	88.36	7.52	1.85	2.27
Rosser	76.52	21.49	.85	1.14
Springfield......	66.08	27.55	6.09	0.29
Roland	95.78	2.74	1.17	0.31
Macdonald	92.49	5.50	1.69	0.32
Morris	92.99	5.58	1.05	0.38
Richot	81.17	12.88	3.98	1.97
Tache	72.12	18.23	7.99	1.66
Hanover	43.72	47.89	5.81	2.58
De Salaberry	75.83	17.75	5.61	0.81
Rhineland	94.49	5.38	0.05	0.08
Montcalm	90.43	5.55	3.61	0.41
Franklin	64.66	30.22	4.32	0.80
Group 2:				
St.James	60.38	37.08	1.47	1.07
East St.Paul	80.64	15.71	2.22	1.43
West St. Paul ...	80.82	18.58	0.52	0.08
Old Kildonan	76.53	23.18	---	0.29
North Kildonan...	80.82	15.99	1.95	1.24
East Kildonan ...	84.62	8.79	4.40	2.19
West Kildonan ...	58.90	39.73	---	1.37
St. Vital	78.35	15.66	5.58	0.41
Fort Garry	76.79	17.70	5.17	0.37
Assiniboia	77.94	18.40	3.07	0.59
Charleswood	78.88	15.99	4.22	0.91
Group 3:				
Woodlands	40.10	53.97	4.49	1.44
Rockwood	52.05	34.49	9.12	4.34
St. Clements	60.13	26.78	10.62	2.47
Ste. Anne	51.66	40.06	7.21	1.07
La Broquerie	30.82	46.16	19.92	3.10
Stuartburn	23.24	62.23	9.68	4.85

(2) SIZE OF FARMS:

The average number of acres per farm in each municipality has been calculated from the Census of Canada data for 1946 as follows:-

Group 1:

St. Andrews	171	acres
Brokenhead	173	"
St. Francois Xavier	407	"
Cartier	477	"
Rosser	343	"
Springfield	161	"
Roland	324	"
Macdonald	402	"
Morris	310	"
Richot	212	"
Tache	203	"
Hanover	154	"
De Salaberry	268	"
Rhineland	184	"
Montcalm	276	"
Franklin	294	"

Group 2:

St. James	89	acres
East St. Paul	39	"
West St. Paul	170	"
Old Kildonan	54	"
North Kildonan	25	"
East Kildonan	9	"
West Kildonan	6	"
St. Vital	77	"
Fort Garry	107	"
Assiniboia	215	"
Charleswood	109	"

Group 3:

Woodlands	409	"
Rockwood	235	"
St. Clements	109	"
Ste. Anne	165	"
La Broquerie	392	"
Stuartburn	210	"

The size of farm holdings in these municipalities has been influenced by a number of factors, such as; the early river-lot system of land survey along the stream banks; the markets for vegetables and dairy products that affect the suburban and rural municipalities adjacent to the cities of Winnipeg and St. Boniface; the open plains in the Central Lowlands that favor mechanized grain growing; the rougher conditions that prevail in the Interlake Reworked Till Plain and in the South-Eastern Complex; and the varied attitudes to land utilization that are characteristic of the various racial groups which make up the farming communities.

(3) TYPE OF AGRICULTURE FOLLOWED:

The type of agriculture followed on the farms in the Winnipeg-Morris area is indicated by the crop acreages and by the number and kind of livestock kept.

Due to the vicissitudes of climate and economic conditions, there is some annual variation in the crop acreage and livestock population. However, although the respective figures vary somewhat from year to year, the agricultural data in the respective municipalities in 1946 reflect quite well the type of agriculture followed.

(a) Crop Acreages:

The total crop acreage figures by district units are not as easily visualized as are figures by farm units. Therefore, to simplify the official crop acreage data, the total figures for the crops and land use in the respective municipalities have been calculated as the average acres per section of 640 acres. By thus expressing the crop acreage figures as acres per section, the general use made of the arable land in the different municipalities of this area can be compared on a common acreage basis.

Table No. 15 shows the various classes of crops, calculated as the average acreage per section of 640 acres for each municipality, except in the case of the municipalities of East Kildonan and West Kildonan which have a total farm acreage of only 91 and 73 acres respectively, and consequently the acreage figures for these two municipalities are given on a municipal, instead of on a 640 acre basis.

The comparative acreage figures for fallow and the various classes of crops grown on the respective municipalities indicate the various types of agriculture followed. Over the larger portion of the municipalities in Group 1, Table No. 15, the arable farm land is under a fallow-grain system, in which the land is used primarily for the production of grain or as fallow preparatory for grain production. A comparison of the acreage in fallow and in grain in these municipalities shows a fairly common ratio of two to three acres of grain to each acre of fallow. This regional system of agricultural land use has been modified in the municipalities of Rhineland, Montcalm, and Roland by the introduction of other crops such as sugar beets, corn, sunflowers, canning peas, etc., and by the use of intertilled crops as fallow substitutes, so that here there is a marked trend toward crop diversification.

The acreage of cultivated hay and pasture crops is relatively limited in the municipalities where grain growing is the dominant type of farming followed, but the somewhat larger acreage of cultivated hay and pasture crops (where they occur) reflects a corresponding amount of livestock farming and dairying that is found locally in association with the regional grain growing type of land use particularly in the northern and eastern municipalities of Group 1.

The acreage figures for the various classes of crops grown on the arable farm land in the municipalities in Group 2, Table No. 15, reflect the proximity of urban markets for dairy and garden products, and indicate the degree to which dairying and market gardening have developed in the suburban and rural municipalities adjacent to the cities of Winnipeg and St. Boniface.

The acreage figures for the various classes of crops on the farm lands of the municipalities in Group 3, Table No. 15, indicate a combination of grain growing and livestock or dairy farming, either in combination on individual farms or as associated types of land use on adjacent farms.

Data are not available which would show the annual yields of the dominant crops by municipalities or by Census districts, but the average mean annual yields of cereal crops from 1921 to 1951 for Provincial Crop Reporting Districts, Nos. 3, 4 and 5,* are submitted in Table No. 16 as evidence of the average annual yields which have been obtained during this period over the major portion of this area.

* Red River, Winnipeg, and Springfield Crop Reporting Districts (Nos. 3, 4 and 5) include all the municipalities in the Winnipeg-Morris area, except Ste. Anne, La Broquerie and Stuartburn, as well as the municipalities of Portage La Prairie, Grey, Dufferin, Thompson and Stanley.

Table No. 15:- Utilization of Land on Farms, Winnipeg-Morris Area. Data for Each Municipality Expressed as Acres Per Section of Farm Land (640 Acres). Census of Canada, 1946.

	ARABLE LAND						NONARABLE LAND		
Municipality	Fallow	Grain Crops	Other Crops	Cultivated Hay & Pasture	Potatoes	Farmstead, Garden, Etc., By Difference	Native Pasture	Woodland	Marsh and Wasteland
Group 1:									
St. Andrews	86.6	215.4	2.1	46.5	7.4	15.4	227.9	32.5	6.2
Brokenhead	96.6	257.5	1.0	41.7	2.7	16.0	159.6	38.9	26.0
St. Francois Xavier	116.8	321.7	2.2	24.8	1.5	8.5	83.9	68.5	12.1
Cartier	156.6	363.1	7.8	29.2	0.8	8.0	48.1	11.8	14.6
Rosser	126.3	314.4	---	31.1	1.1	16.9	137.5	5.4	7.3
Springfield	94.1	259.3	4.2	47.6	4.6	13.1	176.3	39.0	1.8
Roland	107.4	426.8	21.1	46.3	0.2	11.1	17.6	7.5	2.0
Macdonald	153.9	401.0	4.4	25.6	0.2	6.9	35.2	10.8	2.0
Morris	127.7	418.3	7.5	33.4	0.2	8.0	35.7	6.7	2.5
Richot	118.5	310.0	7.3	62.8	4.2	16.6	82.5	25.5	12.6
Tache	79.0	251.7	12.4	89.8	1.0	27.7	116.7	51.1	10.6
Hanover	55.8	160.2	9.4	25.6	3.1	25.7	306.5	37.2	16.5
De Salaberry	141.6	292.1	9.2	34.8	0.7	6.8	113.6	35.9	5.3
Rhineland	66.2	401.3	57.5	64.5	0.7	14.2	34.4	0.3	0.6
Montcalm	89.4	410.6	27.2	45.2	0.4	5.9	35.5	23.1	2.7
Franklin	103.2	264.1	5.1	31.9	0.4	9.1	193.4	27.7	5.1
Group 2:									
St. James	35.0	92.5	16.6	106.6	5.9	129.9	237.2	9.4	6.9
East St. Paul	87.4	225.0	9.8	66.7	34.2	93.0	100.5	14.2	9.2
West St. Paul	128.4	269.0	13.2	70.9	6.6	29.2	118.9	3.3	0.5
Old Kildonan	57.7	291.2	3.0	69.3	30.2	38.5	148.3	---	1.8
North Kildonan	88.0	147.8	19.2	84.1	44.5	133.6	102.4	12.5	7.9
St. Vital	71.7	197.5	12.7	138.7	10.3	70.6	100.2	35.7	2.6
Fort Garry	79.7	194.3	34.0	152.0	9.1	22.3	113.3	33.1	2.2
Assiniboia	105.1	321.8	10.1	50.0	3.5	8.3	117.8	19.6	3.8
Charleswood	111.7	285.8	11.6	72.2	4.8	18.8	102.3	27.0	5.8
East Kildonan*	4.1	---	---	2.0	4.1	66.6	8.1	4.1	2.0
West Kildonan*	1.0	10.4	---	9.3	7.3	13.9	30.1	---	1.0
Group 3:									
Woodlands	67.2	166.1	2.3	11.6	0.4	9.1	345.4	28.7	9.2
Rockwood	86.8	192.9	6.8	33.3	1.9	11.5	220.7	58.4	27.7
St. Clements	69.2	219.5	1.7	43.3	18.2	33.0	171.4	67.9	15.8
Ste. Anne	45.4	152.0	5.1	109.9	1.3	17.4	256.4	46.1	6.4
La Broquerie	10.0	33.5	2.6	141.4	0.9	8.7	295.4	127.5	19.9
Stuartburn	16.4	45.8	0.3	69.6	1.5	15.1	398.3	62.0	31.0

* Total farm acreage 91 and 73 acres respectively. Hence, proportion acreages in these two cases are shown on actual acreage basis.

During the 31 years for which the data are available, the average yields of wheat and other crops show wide fluctuations. These fluctuations are due to the effect of drought, excessive spring moisture, local flooding, wheat rust and other plant diseases, grasshoppers, etc. The reducing effect of these hazardsover long periods should be given due consideration in estimating the productive capacity of the area. Unfortunately, no figures are available for a comparison of crop yields on the respective soil types, but higher average yields than those given in Table No. 16 can be expected on the better soil types and lower average yields can be expected on the inferior soil types.

(b) Number of Livestock:

The number of horses, cattle, sheep, swine and poultry listed for the respective municipalities expressed as the average number per section of 640 acres are given in Table No. 17.

The figures for livestock per section of land, given in Table No. 17, indicate that an appreciable amount of livestock is found throughout the area. They also reflect the stimulating effect of urban or domestic markets for milk, meat and poultry products on the classes of livestock. It is apparent however that this stimulation is not confined to the suburban and rural municipalities immediately adjacent to the cities of Winnipeg and St. Boniface, but it extends also to municipalities lying around the perifery of the Central Lowlands, and within the aspen grove region, where the soils are less suited to extensive mechanized grain growing, and where stock-watering facilities are generally favorable. The lowest numbers of livestock occur in those municipalities o the Central Lowlands within the grassland region and west of the Red River, where mechanized grain growing is strongly entrenched, and an adequate supply of water for livestock, in many cases, may be a problem.

(4) GENERAL OBSERVATIONS:

The present land use in the Winnipeg-Morris area as a whole reflects the influence of both export and domestic markets. The farm lands of this area are suited, and are used in varying degrees, to produce a wide variety of agricultural products. In general, grain growing may be considered as the most widely practised form of agriculture. This form of land use was first developed as the result of (i) the discovery that grassland soils were exceptionally well suited to the production of grain, and of (ii) the development of export markets for the grain that could be produced. However, as the cities of Winnipeg and St. Boniface grew during the years, and continued to expand, a large domestic market developed for a wide variety of agricultural products. This domestic or local market has had a marked effect on land use, not only in the suburban municipalities adjacent to the twin cities of Winnipeg and St. Boniface, but also to some degree, throughout the grassland area, and to a large degree on the farm lands in the municipalities within the aspen grove and wooded region lying north and east of the grassland plain. Thus, in addition to mechanized grain growing there are many farms, in various localities, on which other types of agriculture and land use are practised. These include farms devoted to crop diversification, combined crop and livestock production, stock raising, dairying, poultry products, and market gardens.

The extent of the domestic market for agricultural produce can be inferred from the number of residents in the cities and towns within the area. The

Table No. 16:- Average Yields of Cereal Crops and Potatoes in Manitoba Crop Reporting Districts 3, 4, and 5 (Red River, Winnipeg and Springfield Respectively). 1921 to 1951 (31 Years).

Year	Wheat	Oats	Barley	Fall Rye	Spring Rye	Flax	Potatoes
	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels
1921	15.2	29.5	24.8	18.3*	15.8	10.4	167.3
1922	19.8	36.4	29.7	19.4	18.5	10.9	174.3
1923	11.8	30.0	22.2	15.4	14.4	10.7	110.3
1924	19.3	38.3	29.3	20.8	16.2	10.8	117.7
1925	18.3	43.0	30.7	16.7	16.0	12.1	158.0
1926	23.0	34.9	30.5	18.4	16.2	11.2	149.0
1927	10.8	17.2	22.2	15.0	14.4	9.1	118.0
1928	19.8	36.4	25.1	17.2	14.2	9.7	124.7
1929	15.5	26.6	22.1	16.6	12.4	7.5	63.7
1930	18.6	31.3	25.3	18.5	15.9*	10.2	154.6
1931	15.9	26.6	22.1	16.0*	12.3*	6.6	122.6
1932	15.4	24.0	18.4	14.5*	12.6*	5.1	78.7
1933	14.4	20.3	17.0	13.8	11.9*	6.1	98.7
1934	22.8	31.8	30.7	18.3	16.0*	9.0	112.3
1935	11.4	22.1	22.3	19.6	16.0*	9.4	122.3
1936	14.5	16.2	16.9	11.6	11.0*	5.5	50.7
1937	22.1	41.6	32.0	23.6	17.7*	10.9	147.3
1938	17.1	29.4	24.6	16.4	13.9*	7.7	89.7
1939	20.8	29.4	24.1	16.6	14.0*	6.9	95.7
1940	23.7	32.8	27.0	15.3	15.7	9.5	70.7
1941	20.9	35.8	28.3	17.2	17.1*	8.5	152.7
1942	30.5	49.7	37.7	19.9	21.5*	9.1	135.0
1943	25.0	37.4	25.8	14.6	14.0	9.7	142.3
1944	19.3	35.7	23.4	12.5*	16.0*	10.3	67.0
1945	18.7	27.4	22.8	12.0*	13.5*	10.4	92.3
1946	22.5	32.8	26.0	14.8*	15.0*	9.7	83.3
1947	15.1	27.4	15.2	11.7	11.0*	9.2	126.7
1948	23.6	37.8	30.5	16.5*	14.6*	9.4	117.3
1949	19.7	30.6	22.4	13.6*	10.0*	7.5	68.0
1950	19.8	44.3	33.4	13.5*	14.0*	10.0	88.3
1951	22.9	35.3	28.9	17.4*	13.9*	9.1	143.0
Average of 31 years	19.0	32.0	25.5	16.3	14.7	9.1	114.3

* Average for only two Crop Reporting Districts (3 and 5).

Table No. 17:- Average Number of Horses, Cattle, Sheep, Swine and Poultry by Municipalities in Winnipeg-Morris Area, Manitoba, Expressed as Average Numbers Per Section of Land (640 Acres). Census of Canada, 1946.

Municipality	Horses	CATTLE		Sheep	Swine	POULTRY	
		Milk Cows	Other Cattle			Hens and Chickens	Other Poultry
Group 1:							
St. Andrews	8.8	19.4	13.1	5.0	20.4	434.7	26.0
Brokenhead	11.7	25.5	11.0	2.7	23.7	598.8	47.7
St.Francois Xavier	4.0	10.8	7.6	2.7	11.3	250.1	7.2
Cartier	4.1	8.9	5.7	10.4	36.0	375.7	92.4
Rosser............	4.7	16.3	8.2	3.1	13.2	327.8	17.2
Springfield	9.0	21.7	8.9	2.7	15.7	542.9	33.9
Roland	4.9	8.0	13.7	2.3	13.4	444.2	14.6
Macdonald	2.0	7.1	4.2	.8	6.8	362.4	10.2
Morris	3.5	8.7	5.6	.6	19.3	545.8	13.2
Richot	6.9	16.9	8.5	1.4	16.5	781.3	13.7
Tache	7.4	30.2	9.8	5.0	15.3	571.7	16.0
Hanover	10.9	32.7	15.8	9.9	24.7	970.4	25.5
De Salaberry	5.6	17.0	7.3	5.6	16.8	402.4	13.1
Rhineland	7.5	17.0	9.8	4.4	23.8	1,010.6	20.6
Montcalm	5.2	15.5	8.1	1.5	15.4	562.9	15.9
Franklin	6.8	17.8	14.4	7.6	14.7	340.6	25.4
Group 2:							
St.James	21.9	89.3	22.5	---	33.1	2,840.6	.6
East St. Paul	8.3	14.2	5.6	.1	43.7	1,531.3	12.6
West St. Paul	7.3	25.4	9.5	---	15.1	695.9	11.8
Old Kildonan	19.7	54.7	7.5	---	21.6	1,480.7	94.7
North Kildonan....	16.3	25.0	9.1	---	33.4	3,345.2	26.2
St.Vital	9.2	27.0	9.1	10.4	17.6	2,226.3	15.8
Fort Garry	11.3	66.0	11.3	.1	35.5	820.6	14.8
Assiniboia	5.6	19.2	7.4	.4	27.6	408.2	6.1
Charleswood	7.6	21.6	15.2	2.4	20.0	1,061.3	13.9
East Kildonan* ...							
West Kildonan* ...							
Group 3:							
Woodlands	7.3	15.5	20.6	6.4	9.0	222.1	14.3
Rockwood	9.6	24.0	10.1	11.6	21.9	337.6	28.2
St. Clements	10.5	21.8	11.3	4.5	21.7	638.3	24.2
Ste. Anne	10.0	33.2	13.5	6.3	18.9	719.1	12.4
La Broquerie	6.1	17.3	7.9	3.2	6.4	152.1	9.7
Stuartburn	10.6	32.2	19.1	26.8	10.4	213.8	35.7

* As East Kildonan and West Kildonan had only 91 and 73 acres, respectively, of land "held as farms" in 1946, the acreage figures for these two suburban municipalities are obviously not suitable for comparison on a section basis.

population of Greater Winnipeg, which includes the City of Winnipeg, City of St. Boniface, St. James, Fort Garry, St. Vital, East Kildonan, West Kildonan, Brooklands, and Tuxedo as listed in 1951 is 340,872 persons. The population of the larger towns scattered throughout the area, as listed in 1951, includes Transcona, 7,800; Selkirk, 5,370; Steinbach, 2,100; Beausejour, 1,376; Altona, 1,231; Morris, 1,200; Stonewall, 1,071; Emerson, 900; Gretna, 608; and in addition there are the residents in a number of smaller villages. Not only do these cities, towns and villages require agricultural products for subsistence, but processing plants are in operation, many of which supply products to points outside the Winnipeg-Morris area. Processing plants for agricultural products in Greater Winnipeg include flour mills; oatmeal and rolled oat mills; biscuit, spaghetti, and potato chips factories; malting plants; breweries; sugar beet factory; vegetable canning and pickle factories; linseed oil plants; alfalfa meal processing plants; animal and poultry feed plants; meat packing plants and abattoirs; creameries, dairies, and milk powder plants; tanneries; woolen mills; egg candling and poultry dressing stations; etc. Some of the country towns also have plants for the processing of agricultural products, such as the Co-Operative Vegetable Oils plant at Altona. The location of grain elevators, loading platforms, stock-shipping facilities, and creameries at rural points in the Winnipeg-Morris area are listed in Appendix III.

As industrialization proceeds in the towns and villages within this area, and as local markets for agricultural products increase, a corresponding increase in agricultural diversification and modification of land use can be expected. This future expansion of industry and population, however, does not exhaust the possibilities of agricultural development. For example; the soils of the grain-growing section of the Red River Plain are equally suited to the production of alfalfa and grass-legume mixtures. Such alfalfa and mixed hay crops could be used extensively as soil-improvement crops, in an improved land-use program, along with grain growing, and the roughage thus produced could be used along with grain and other supplementary feeds for stock feeding. Thus, soil-improvement crops as well as grain could be produced during the growing season, instead of so large an acreage on the clay soils being devoted to summerfallow, and cattle feeding or stock fattening could be carried on during the winter months. The expansion of market gardening and the production of canning crops and sugar beets under irrigation is a further possibility. A limited number of operators, located along the Red River, already are pumping water from the river and applying it by the spray system of application to truck crops. This system could be extended along both the Red and Assiniboine rivers, as markets are found for the increased products that could be produced by this system of land and water use. The major problems in further development of diversified agriculture in the prairie section of the Central Lowlands are water supply and drainage. These problems are dealt with under a separate section of this report. The various land-use problems peculiar to the respective soils are tabulated in Table No. 6.

Further information in respect of the crops that can be produced, the soil management practices suited to the various soils, and the land-use systems that can be followed in this area can be obtained from the Agricultural Faculty, The University of Manitoba, Fort Garry; from the Extension Service, Provincial Department of Agriculture, Winnipeg; and from the Dominion Experimental Station, Morden, Manitoba.

7. WATER RESOURCES AND DRAINAGE:

An adequate supply of water is essential to plant, animal and human life, but an excess of water can be a serious handicap. The quantity of water available in any region is one of the prime factors in determining the amount of life that the region will support. Because of the importance of water in land utilization, the following outline of the water resources and drainage in the Winnipeg-Morris area is included in this report.

A. WATER RESOURCES:

The natural water resources of this area are here dealt with under the headings of (1) Source of water; (2) Water retained by soils; (3) Surface waters and (4) Ground water.

(1) SOURCE OF WATER:-

The primary source of water is precipitation. The annual precipitation in the vicinity of Winnipeg (as shown in Table No. 2) averages 20.49 inches. From a soil and crop production standpoint, however, the precipitation must be considered by seasonal, rather than by yearly totals. During the months of April to October, the mean monthly temperatures are above freezing, and the precipitation during this period (which averages 76.8 percent of the mean annual total) may be considered as rain that falls on unfrozen ground. Of this open season precipitation, an average of 9.58 inches (or 46.7 percent) falls during the months of April to July, (i.e. the grain-growing period) and an average of 6.17 inches (or 30.1 percent) falls during August to October (i.e., the harvest and fall months).

During the months of November to March, the mean monthly temperatures are below freezing, (as shown in Table No. 3) and the 4.86 inches of precipitation that falls during this period (and which averages 23.2 percent of the total) may be considered as snow that falls on, and accumulates above, frozen ground. Part of this snow sublimates or evaporates during the dry cold days of the winter period, but during the spring thaw any remaining snow melts and, as long as the ground is frozen, the snow water moves or remains as surface water that cannot percolate readily into the ground until the frost disappears. Insofar as the snow water evaporates or runs off as surface flow, there is that much less water available for crop production at the site of snowfall; and moreover, the accumulation of surface run-off from this source adds to the drainage problem in depressional sites. It is obvious therefore that the humidity or aridity of the well-drained soils is determined more by the amount of rain which falls when the ground is not frozen (i.e.; during the fall months and the summer growing season) than by the amount of snowfall; and that the amount of run-off in the early spring is conditioned by the quantity of snow and the rate at which it thaws, and by the frozen or unfrozen condition of the soil.

The precipitation figures, during the growing season, fluctuate widely from the mean values here given. In sub-normal precipitation periods, the low availability of moisture in the grassland region may approach drought conditions, and in above normal precipitation periods, excessive amounts of moisture may result in local flooding and in aggravation of drainage problems.

In addition to the water which falls on the land within the area, the Central Lowland is also subject to invasion by foreign waters which flow in, as surface run-off, from the adjacent higher lands to the west, south and east.

Artesian water also is of local importance in the southeastern portion of the Winnipeg-Morris area. While this supplies water for domestic and stock use, it also invades the substrata and subsoils of some soil associations and provides water that may be available for plant use. In other cases the rise of ground water may result in surface swamping and local aggravation of drainage problems.

(2) WATER RETAINED BY SOILS:

The conservation of water for crop use should begin with the storage of water in the soil. All the precipitation which falls as rain does not enter the soil. A portion is intercepted by the vegetation, and evaporated back into the air. There is also a loss of water by evaporation if rain water fails to penetrate into the soil, or if it penetrates only to a slight depth. Moreover, run-off occurs if rain falls faster than it can penetrate into the soil. The amount of run-off is influenced by the rate and intensity of precipitation; by the texture, porosity and organic content of the soil; by the surface cover; by the degree of surface slope; and by the presence or absence of frost in the ground. Therefore only a portion of the seasonal precipitation enters the soil, and this amount varies in different seasons and in different textural soils. As the varying proportions of the precipitation enter the respective soils, the water is subject to the action of opposing physical forces. The force of gravity acts to pull the water downwards, but the forces of cohesion and surface tension act to hold the water around the soil particles, and consequently, unless more water enters the soil at a given level than can be retained around the soil particles by physical forces, there can be no percolation of water to lower levels and the water is retained as "hanging" water. The amount of water that can be retained by soils is determined by the texture or size of the mineral particles and by the amount of organic matter present.

The amount of water that can be retained by the chief soils of the Winnipeg-Morris area, is given in Table No. 9. These amounts represent the maximum quantity of water above the wilting point that can be retained in the respective soils under free drainage, but the amount of water actually held under field conditions varies from time to time -- decreasing under plant growth, and increasing to a possible maximum under fallow in favorable seasons, or in moist periods when precipitation is more than adequate to supply the needs of the growing plants. From the figures given as the amount of water retained above the wilting point by the representative surface soils listed in Table No. 9, it may be calculated that the soils of the Red River association (which constitutes 47 percent of the area) have a water retention capacity above the wilting point of around 3 inches per foot. The Saltel soils, which occupy only a very small area have a similar water retention capacity. The Fort Garry, the Marquette, the Riverdale, the Oakville, the Lakeland and the Isafold soils, (which together constitute approximately 10 percent of the area), have a calculated water retention capacity of between 2.6 and 3 inches per foot. The Semple, the Emerson, the Garson, the Zora, the Woodlands, the Altona (fine loam), the Red River-Emerson transition, the Steinbach, the Sperling, the Peguis, and the Brokenhead soils, (which together constitute approximately 20 percent of the area), have a water retention capacity of between 2.0 and 2.5 inches per foot. The Kittson and the Pelan soils (which constitute about 5 percent of the area) have a water retention capacity of between 1.6 and 2 inches per foot. The Altona (sandy loam) the Springbank, the Pine Ridge, the Leary, the Vita, and the Tolstoi soils (which together also constitute about 5 percent of the area), have a water retention capacity of between 1.0 and 1.5 inches of water per foot. The Poppleton and Menisino soils have a water retention capacity of between 0.5 and 1.0 inches of water per foot. These values are calculated from the moisture equivalent values of the respective surface soils. It should be noted however, that the moisture equivalent values for the soil profiles in the charts presented as Figures No. 50 to No. 61 show that, except in the case of very fine clays, water retention capacity decreases with depth. Thus, the water retention capacity of the various soil profiles below the organic accumulation, in **most** cases, will be less than the values given above for the respective surface soils. It is highly significant that from three-quarters to four-fifths of the soils in this area have the capacity to retain from two to three inches of available water per foot. This high water retention capacity is characteristic of fine textured soils. Fine textured soils, unless they have well-developed granular structure, generally have relatively low porosity. Under flat topography, these soils tend to have slow internal drainage and, in depressed positions, are invariably under the influence of poor drainage.

Only a relatively small percentage of the area is occupied by soils of coarse texture. On the one hand, coarse textured soils, and soils with gravelly or sandy subsoils, such as the Agassiz, the Poppleton, the Menisino, the Pine Ridge, the Leary, the Vita, and the Tolstoi soils, etc., tend to be somewhat droughty in the well-drained positions, because of low water retention capacity, high porosity, and excessive internal drainage. On the other hand, due to low water retention capacity, large pore spaces, and free movement of water by gravity, the coarse textured subsoils of these associations are aquifiers, which (under the rainfall of this region, and where they are underlain by impervious substrata or where they occupy depressional positions) favor the accumulation of ground water.

(3) SURFACE WATERS:

(a) Lakes, Sloughs and Bogs:

It is of interest to note that, in the areas covered by the Winnipeg and the Morris soil map sheets, which lie entirely within the region once covered by glacial Lake Agassiz, lakes are of little or no significance at the present time. The small lakes and ponds, that were mapped at the time of the soil survey, together constitute only .05 percent of the total area.

In the grassland region of the Central Lowlands, the only natural bodies of standing water that may be considered as perennial lakes, are:-

(i) Lake Louise in Sections 11 and 14, Township 1, Range 2 east; which is approximately one and one-third miles long and up to three-twentieths of a mile wide;

(ii) The so-called Buffalo Lake in Township 2, Range 1 and 2 west, which is merely a wider portion in the upper section of the Plum River channel, that is about nine miles long; and

(iii) The oxbows or curved lakes in abandoned water courses within the channels of the Red and the Assiniboine rivers. Throughout the flat clay plain of the Central Lowlands, intermittent sloughs or temporary ponds may occur in the hydromorphic depressions during wet periods, but these bodies of water are very shallow and disappear in normal or dry seasons.

In the eastern forested region where the terrain has more relief a few permanent ponds or small lakes are found, but they are neither numerous nor extensive.

One small pond is found in Section 12 and 13, and another in Sections 5 and 6 in Township 3, Range 5 east; a small lake, that is half to three-quarters of a mile long and three-twentieths of a mile wide is located in Sections 4 and 5, Township 1, Range 7 east; a small body of water, one-third of a mile long and one-fifth of a mile wide occurs in Sections 20 and 29, in Township 3, Range 8 east; and a small pond or slough in Section 16, and a small lake in Sections 9 and 16, are to be found in Township 7, Range 8 east. Several small ponds are associated with Half-Bog soils in Townships 5 and 6, Range 7 east; and in Township 5, Range 8 east. In Township 7, Range 7 east, there is a body of water one and a quarter miles long and four-fifths of a mile wide, and in Township 11, Range 8 east, there is a smaller body of open water, two-fifths of a mile long and wide; these two areas of surface water are associated with, and enclosed by, muskeg and Bog soils.

Although the total surface area of open water in lakes and ponds is less than three sections, there are 149,248 acres (or approximately seven townships) of Bog and Half-Bog in the eastern forested portion of the area. These are sites that are periodically more or less saturated with surface waters, or where accumulated aquatic vegetation has converted ponded water surfaces into organic surface deposits. These sites are perennially hydromorphic.

(b) Rivers and Streams:

Except for a small portion in the northeast corner, that is part of the Brokenhead River system, the area covered by the Winnipeg and Morris soil map sheets is drained exclusively by the Red River and its tributary streams, supplemented by the man-made drainage channels that discharge into the natural stream channels. The Red River enters the Morris soil map sheet area at the International Boundary in Section 2, Township 1, Range 2 east; and flows nothward through the Central Lowland plain. After being augmented by the Assiniboine River at Winnipeg ("The Forks") it continues northward and discharges into Lake Winnipeg, some 10 to 11 miles north of the point where it passes out of the Winnipeg soil map sheet area, in Section 34, Township 14, Range 5 east.

Except for the Assiniboine River, the only natural tributaries, within the Winnipeg-Morris area, that flow in the Red River from the west are the Marais, the Plum, the Morris, and the Sale (or La Salle) rivers which could be classed more correctly as periodically intermittent streams or creeks rather than rivers. During summer droughts, these tributary stream channels may be dry, but during spring break-up and following heavy rainstorms in wet seasons, flash and flood waters may not only fill the channels, but at times, may overflow their banks. The land south of the Assiniboine and west of the Red River is flat with only micro-relief, and this portion of the area depends to a large extent for its drainage on the man-made drainage channels which supplement and discharge into the natural streams. Here, because of the flat topography and the prevailing clay texture of the surface deposits, the natural streams were ineffective in providing adequate drainage of the lands through which they pass. Moreover a number of creeks and intermittent streams originate in the Pembina Hills and flow from the west in to the Central Lowlands. Due to their periodicity and the low grade of the lowlands plain, the waters of these streams, in many cases, were unable to cut continuous channels eastward to the Red River, and, prior to the installation of the vast network of man-made open drains, these waters spread over the meadow areas known as the Boyne marsh and the Tobacco Creek marsh.

In the area north of the Assiniboine River and west of the Red River natural drainage is sluggish and rudimentary. Except for the intermittent Sturgeon

Creek, which flows into the Assiniboine, there is no natural stream worthy of a name. Portions of the area were referred to by the early settlers as, the White Horse plains, the Frog plains, and Clandeboyne marsh. Some local systems of man-made drainage channels have been installed, but here a complete overall system of drainage has yet to be developed.

The natural tributaries which flow into the Red River from the east are the Joe River, the Roseau River, the Rat River with its tributaries the Marsh and the Joubert; the Seine River and Cook's Creek. The largest of these tributary streams rise in the eastern forested region and are fed from water ponded in the bogs and swamps. Consequently the tributaries which flow into the Red River from the east are more or less continuous, and less erratic than those which flow in from the west.

The role played by the Red River in the historic past, and which it plays in the present, and will continue to play in the future economy of the Winnipeg-Morris area, is highly important.

The amount of water carried into the Red River system at Emerson by the Red River itself, and the amount of water delivered by the chief contributary streams at points close to their discharge into the Red River, within the Winnipeg-Morris area, are shown in Table No. 18. This table shows the mean monthly discharge, the maximum mean monthly discharge, and the minimum mean monthly discharge, recorded in cubic feet per second, by months, for the periods and streams for which such information is available.* No information is here available in respect of the smaller tributaries which, though they are more or less intermittent, deliver additional amounts of water into the Red River, especially during spring run-off and following heavy summer rainstorms.

The figures in Table No. 18 show that normally the peak flow in the Red River and its tributaries occurs during the months of April and May and that the lowest discharge is during the month of February. However, wide differences in discharge occur year by year in the respective months. The wide variation in discharge of the river and its tributaries is characteristic of prairie streams. During dry seasons, when more water is required for the irrigation of market gardens, the flow in the case of some tributaries is reduced to zero, so that the use of such tributary waters for irrigation is subject to serious limitations. On the other hand, the relatively high level of water in the river and its tributary streams during the months of April, May and June predisposes to spring flooding of the lowlands where stream banks are low. During the spring flood of 1950, the Red River at Emerson had a maximum discharge of 94,400 second-feet, and at Winnipeg it had a maximum discharge of 103,440 cubic feet per second. As these rates of discharge were far in excess of the stream channel capacity large areas of the Central Lowland plain were inundated. (See River Floods Page 92).

(c) Dugouts And Storage Ponds:

The conservation of surface water through the use of dugouts and storage ponds is a practice that has long been in use on the farms located in the Central Lowlands where adequate supplies of good well water are often difficult to obtain. The Government of Canada, under the Prairie Farm Rehabilitation Act (P.F.R.A.),

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* The hydrological data here presented was supplied by courtesy of B.B. Hogarth, Provincial Water Resources Branch, who obtained same from Water and Power Branch, Canada Department of Mines and Resources.

Table No. 18:- Monthly Discharge In Second-Feet of Red River And Its Tributaries From Gauge Readings By Dominion Water and Power Bureau.

	Red River at Emerson (1912 to 1952)			Assiniboine River at Headingly (1913 to 1952)			Roseau River at Dominion City (1913 to 1952)**			Rat River at Otterburn (1912 to 1952)**			Seine River at Prairie Grove (1915 to 1936) and (1942 to 1952)**		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	579	2050	7.1	249	592	65.0	20.7	48.8	3.0	5.8	16.2	0.0	6.4	10.7	2.0*
February	550	1910	1.2	223	448	73.0	14.9	49.4	0.0	4.5	13.0	0.0	3.9	7.0	2.1*
March	1500	9120	2.3	382	1180	90.0	48.3	258.0	4.0	12.6	775.0	2.0	6.9	1140.0	3.2*
April	10500	28900	1280.0	4050	9360	577.0	894.0	2270.0	174.0	378.0	1370.0	75.0	316.0	858.0	48.1
May	6900	72800	663.0	5111	16900	725.0	903.0	5050.0	65.0	308.0	2250.0	43.8	246.0	1190.0	22.2
June	4080	22300	196.0	2900	10000	383.0	506.0	2160.0	39.9	165.0	1450.0	22.3	118.0	679.0	10.9
July	2980	13100	121.0	2180	5580	257.0	369.0	1620.0	8.8	90.1	512.0	1.6	53.0	433.0	0.0
August	1390	5100	46.6	1130	4000	226.0	146.0	941.0	0.9	40.1	237.0	0.1	66.0	378.0	0.0
September	1200	4220	39.9	722	2020	184.0	134.0	692.0	0.9	59.9	647.0	0.3	102.0	721.0	1.0
October	2720	3330	46.1	672	2260	211.0	178.0	1470.0	8.3	86.9	480.0	11.0*	62.0	179.0	5.0*
November	1120	2340	23.7	535	2070	158.0	142.0	618.0	8.2	85.8	393.0	12.0*	78.0	236.0	12.6*
December	974	2730	41.7	346	1090	112.0	42.2	380.0	*11.0	13.2	30.0	5.0*	12.0	16.8	7.3*

* No records in some years for months so designated; hence, minimum could be lower and perhaps 0.0.

** Records not complete, especially for winter months.

subsequent to 1935 adopted a program of water development to conserve water for domestic and stock watering purposes in the P.F.R.A. area of Western Canada. Under this program a stock-watering dam has been installed on the Sale River at La Salle, with a storage capacity of 900 acre-feet. A similar project is under development on the Plum River to provide for water storage in Buffalo Lake. However the major P.F.R.A. contribution to water storage in this area has been the assistance given towards the installation of the hundreds of dugouts that have been financed under this scheme, and which have supplemented the numerous dugouts constructed during previous periods under farmer and municipal initiative.

(4) GROUND WATER:

The most extensive records on wells and water supply that are available have been compiled by W.A. Johnston in Memoir 174, Geological Survey, Canada Department of Mines, entitled "Surface Deposits and Ground Water Supply of Winnipeg Map Area, Manitoba". The following information has been summarized largely from this report, supplemented by observations made during the soil survey.

The scarcity of easily accessible, good quality well water is a limiting factor in the development of diversified agriculture over a large portion of the Winnipeg-Morris map area. Throughout the Central Lowland plain, shallow wells in the clay textured surface deposits often yield little or no water, and although an abundant supply can sometimes be obtained from sand or gravel lenses in the lower part of the surface deposits, or from the bedrock below, the water is usually quite saline and therefore of limited value. For this reason, dugouts are used extensively in the lacustrine plain as a source of water for stock and domestic purposes, and drinking water is obtained from river ice at some points along the rivers. Many of these dugouts are too small to insure an adequate supply of water in all seasons, but this could be remedied by increasing the size and depth of undersized dugouts.

The lack of an abundant supply of good quality well water has been a serious handicap to industrial development and to the installation of modern sanitary facilities in the towns and villages throughout the southern and western portion of the Central Lowland plain. The expansion of local industries that have been introduced has been greatly hampered by this condition. The solution to this problem, and the development of a more diversified agriculture in the Central Lowland plain, in all probability would result in a more rapid growth of the small towns and villages in this section of Manitoba.

Artesian water is found in the southeastern portion of the Winnipeg-Morris map sheet area. This area is described as extending east of the Red River to the abrupt rise of land east of Bedford and Piney; west of the Red River to Gretna and Lowe Farm; and north from the International Boundary to Dufresne and Niverville. The total area involved is about 1,200 square miles. The source of this artesian water is the precipitation which enters the deep sand deposits on the highlands to the east, and penetrates to the lower portion of the surface deposits and the bedrock below. The resulting ground water, thus derived, flows west and southwest in the direction of the dip of the rock beds. This water becomes confined beneath the impervious beds of clay and the underlying rock and because the surface of the ground is lower here than in the highland area, artesian conditions are produced. This artesian water may be obtained from various source beds lying at different depths. At some locations it is found in sand and gravel lenses in the lower reaches of the surface deposits (75 to 200 feet below the surface), while in others it may be obtained from sandstone and limestone strata (230 to 450 feet below the surface).

In the eastern portion of this area, the water is usually of good quality, but west of a line which runs approximately from Ridgeville through Arnaud to Ste. Agathe the water becomes progressively more saline.

Another area where artesian water may be obtained occurs north of the Assiniboine River, particularly in a small area north of Winnipeg. Numerous wells in this area served as the source of water for the City of Winnipeg until 1917, when, due to the growth of the city and the depletion of this water reservoir, another source had to be found. Since then the water supply for Greater Winnipeg Water District has been obtained from Shoal Lake, on the boundary between Manitoba and Ontario, by means of a buried concrete pipe line 97 miles long. After disuse of these wells north of Winnipeg, the local water level has gradually risen so that an adequate supply of good water for local use is again insured. This water is found in gravel at the base of the surface deposits, and in the bedrock below, at various depths from 15 or 20 feet to about 150 feet.

Generally, in the South-Eastern (lake-terrace) Landscape Complex that lies east of the Central Lowlands, well water supply is not a serious problem. In addition to the artesian waters which are obtainable at various depths from drilled wells, good quality water may be obtained at shallow depths in the numerous sand and gravel ridges which traverse the area. However, shallow wells dug in these deposits derive their waters from local seepage, and hence the supply of water may become somewhat limited during dry seasons.

Further details in respect of surface waters in this area, if required, can be obtained from the Water Resources Branch, Provincial Department of Mines and Natural Resources, Winnipeg.

B. DRAINAGE

(1) LAND DRAINAGE:

The natural drainage channels and river systems have been outlined above under "Surface Waters" (Section 7A(3)); furthermore, the physical features of the terrain, together with a landscape map, contour map, and a description of the various landscape areas, have been presented in Section (2) of this report. The information thus presented, and the extent of the flood plains, river overwash deposits, and hydromorphic soils shown on the soil maps, reveal the general widespread drainage problem which exists in the flat Red River Plain, and the local drainage problems that occur in the meadow, half-bog and bog areas of the South-Eastern (lake-terrace) Complex.

The area of flat topography lying below the 850 and 825 foot contours (See pages 2b&4a) consists largely of fine textured clay deposits that are imperfectly to poorly drained. Moreover, the precipitation which falls here is augmented by sheet runoff and intermittent streams which enter the area from the higher lands of the escarpment to the west, and from the lake-terrace area to the east. Due to insufficient fall across the clay plain, many of the intermittent streams of foreign waters were unable to cut adequate channels and, in former times, were lost in marshes or meadow areas such as the Boyne marsh and the Tobacco Creek marsh. Consequently, as settlement proceeded, and land development expanded, these marsh areas were artificially drained by large open ditches which were contructed to carry the water of intermittent streams to the Red River or to one of its tributaries. (See Figures No. 62, 63, 64 and 65.)

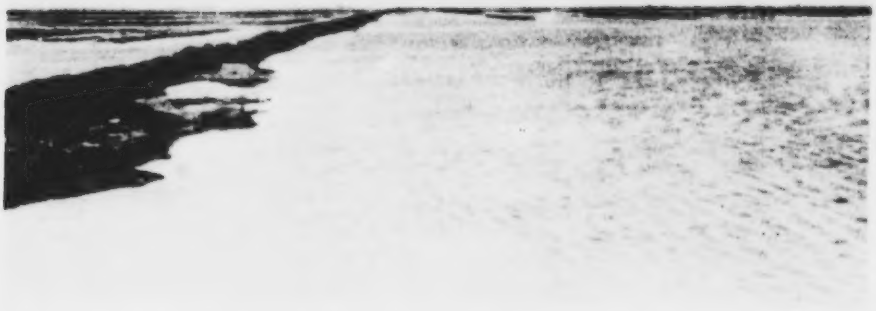

Figure No. 62
Surface flooding of farms, on Osborne clay, Central Lowland area, by water from melting snow during spring thaw.

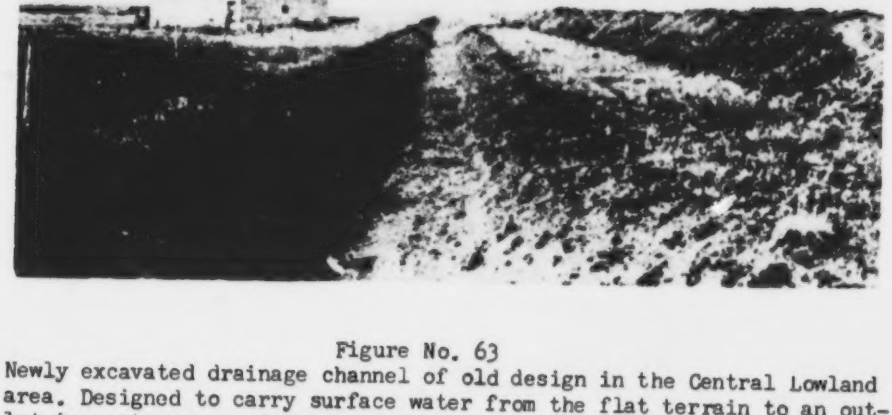

Figure No. 63
Newly excavated drainage channel of old design in the Central Lowland area. Designed to carry surface water from the flat terrain to an outlet in a stream or river channel.

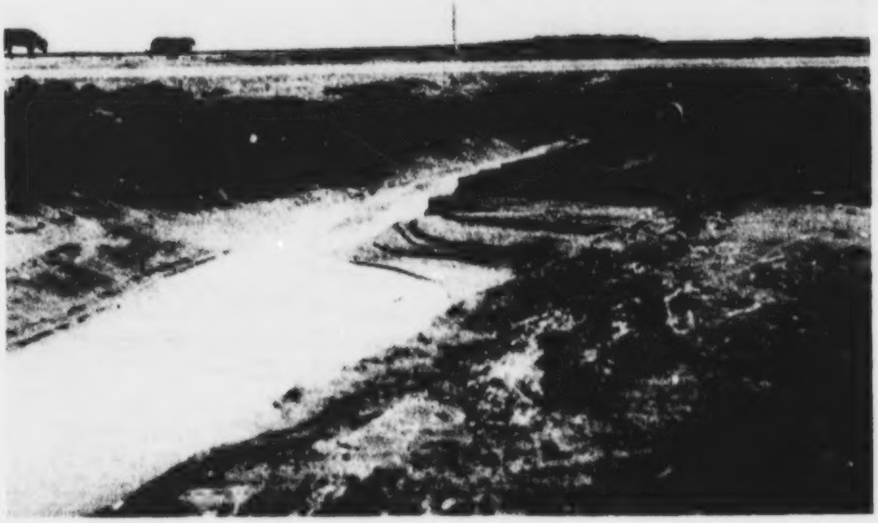

Figure No. 64
Newly excavated drainage channel in a field under fallow partially filled by delta of clay soil deposited by run-off from adjacent field.

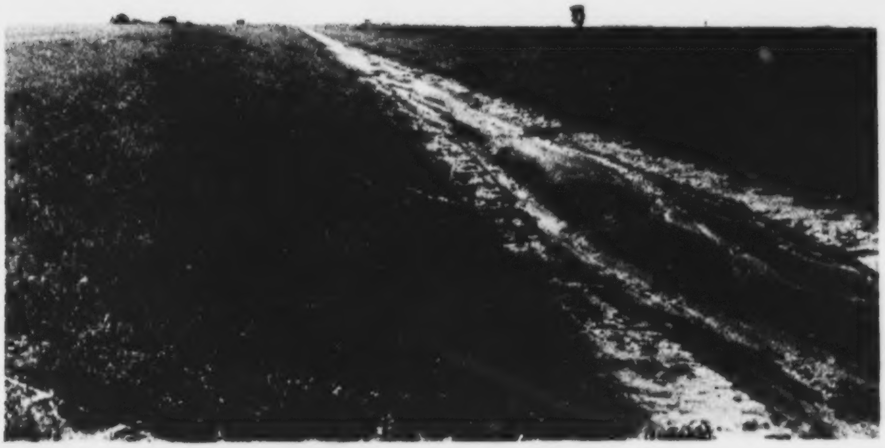

Figure No. 65
Drainage channel backsloped to give a broad shallow water runway with gentle slopes, and newly seeded down to grass to reduce erosion by flash waters.

Ultimately, to meet the general drainage problem of the Manitoba Lowlands, drainage districts were organized under a "Drainage Maintenance Board" composed of representatives of the Provincial government and of the municipalities concerned. The lands in the Winnipeg-Morris area within which the district drains are now under the jurisdiction of the Manitoba Drainage Maintenance Board and are shown in Figure No. 66. *

However, in addition to district drainage projects, land drainage in the Central Lowlands requires additional and appropriate action on the part of individual farm operators if maximum control of drainage on individual holdings is to be obtained.

The protection of the extensive system of open drainage channels has become a serious problem. The flat topography of the imperfectly drained plain, and the absence of trees or other natural barriers to the unhampered movement of winds over the surface, predisposes to movement of soil material, especially when land is fallowed and when soil is pulverized by alternate freezing and thawing in the absence of a snow cover. Under these conditions, soil from fallow and unprotected fields is carried or rolled into adjacent ditches. In some cases fairly large ditches have been more or less completely filled with soil drift. The periodic cleaning out of the drifted soil material from the drainage channels necessitates recurring heavy expenditures. This problem would be of much less importance if land operators maintained a trash cover on the surface after cereal crops have been harvested, and if cover crops were sown on fallowed lands where trash has disappeared.

To aid in the protection of open ditches from soil drift and to reduce the cost of their maintenance, it is recommended that tree hedges be planted and maintained parallel to the drainage channels. These hedges should be planted on that side of the ditches opposite to, and at sufficient distance (120 feet±) back from the spoil banks, so that snow drifts would not accumulate unduly over the ditches. The establishing of hedges and seeding down of the strip between the hedges and the ditches to grass would be a real safeguard. In selecting hedge material for planting alongside drainage ditches, the limitations of trees and shrubs that propagate readily from seed should be recognized. Such species should be avoided because the moist soil of the ditches and ditch banks favor the germination of tree seeds. Hence seed-bearing trees tend to spread and to develop a ribbon of forest growth within the ditches. Moreover, as the drains invariably traverse the less well-drained positions of the terrain, trees and shrubs that require well-drained sites are also unsuitable. Tree willows, propagated by cuttings from male plants, are most suitable. Their economic value as fence posts and fuel in an area where these commodities are absent, together with their moisture tolerance, rapid growth, and serviceability as hedgerow plants, makes them particularly desirable for ditch protection. Fruit-bearing shrubs to provide food for birds, etc., should be placed at intervals in such protective hedgerows.

Micro-relief plays an important part in relation to land drainage on the farms in the clay plain of the Central Lowland. Even where the topography appears flat, slight depressions that are only a few inches in depth below the general level are common. Not only do these micro-depressions hold water from melted snow or as the result of heavy rains but, during and after heavy rainstorms, drainage ditches may overflow and inundate adjacent farm fields, thus causing water to pond over the depressed sites. Two lines of action to reduce or eliminate standing water on farm fields are highly desirable. The first is the construction of a low dyke parallel

* If further information in respect of these district projects is required, it may be obtained from the Chairman, Drainage Maintenance Board, Government Buildings, Broadway Avenue, Winnipeg.

with, and back from, any drainage ditch that carries foreign water, and the second is the systematic construction of shallow farm drains coupled with the building-up or filling-in of the mirco-relief areas with soil material excavated from such drains.

In practice the district drains, constructed to carry water through an area, are usually excavated by means of dragline machines and the spoil banks are eventually made into raised roadways. By this method, dykes are formed on one side of the drain only. A low dyke constructed 100 to 150 feet or more away from the ditch, on the farmed land opposite such a spoil bank, would provide a safety runway in case flash run-off waters were in excess of the capacity of the dug channel and would prevent inundation of the adjacent farm land from ditch overflow.

Many farms in this area have a fall of only one to two feet per mile. On such flat lands the fields should be laid out parallel to the district drainage channels, and a shallow runway twelve to eighteen inches deep installed between each field. If these shallow runways or farm ditches are excavated by a scraper or carry-all type of implement, the excavated soil material can be carried and spread either over the micro-relief depressions or over the lineal centre of the respective fields thus achieving two desirable objectives: (i) farm drainage ditches constructed in this manner are not handicapped by a spoil bank and can be crossed easily by farm machinery; and (ii) the micro-depressions or shallow potholes that hold surface water can be eliminated, and the centre of the elongated fields can be raised to a slightly higher level if, in addition, they are worked towards the centre with a land leveller.

The internal drainage of the soils that are utilized in a fallow-grain sequence of cropping could be improved by the periodic use of tap-rooted legumes. For example, the common cropping sequence on many grain farms is: First year — fallow; second year — grain; third year -- grain. Under this scheme the clay soils tend to become lower in organic matter and less porous with time, especially if the straw or crop residue is burnt. To ensure the maximum levels of organic matter in the surface soils and of porosity in the subsoils under this type of land use, the crop residues should be returned to the land and sweet clover should be sown with the grain in year three. Thus year one of the rotation would then become sweet clover - fallow. In year one, the clover could be cut for hay, or used as pasture, or plowed in as green manure. Ammonium phosphate (11-48-0), or its equivalent, applied with the grain in year two, and ammonium phosphate (16-20-0), or its equivalent, applied with the grain sown in year three, would offset any tendency towards reducing yields; and as the tap roots of the clover decomposed, the root channels would tend to improve porosity and internal drainage.

Investigations conducted by the Soils Department at The University of Manitoba, show that alfalfa grown as a semipermanent hay crop reduced the available water in the subsoil to a low level, and in one fall, 12 inches of water were required to bring the moisture content of an eight-foot column of clay textured soil under alfalfa up to its optimum field moisture. In comparison, fallowed land in the fall of the same season was not only moist throughout but, in addition, contained gravitational or excess water in the fifth-foot depth. In the same fall, stubble land that had grown a grain crop contained six inches more water in the upper seven feet than did the soil under alfalfa. It is obvious therefore that the more extensive growing of alfalfa in semipermanent fields for hay, and in regular rotation mixtures with meadow fescue or mixed grasses for hay and pasture, would materially reduce the hazard of surface-standing water on arable fields in the Red River Plain.

Drainage of the local meadow soils in the South-Eastern Complex does not present any abnormal problems, providing suitable outlets can be located and suitable drainage works installed. One point that should be stressed however is that farm drainage projects should be integrated with municipal or district projects and that drainage control should be planned as integral parts of the watershed as a whole, and in cooperation with local and district drainage administrators.

A further point to be noted in the drainage of peat or bog soils in the South-Eastern Complex area is that such projects involve "drainage-with-control" Open drains that are dug into organic soils should be furnished with suitable controls or checkdams so that the moisture condition within the peat can be controlled as required. Uncontrolled and excessive drying of peat or organic soils provides a fire hazard, and when fire has once started in deep dried peat the results can be disastrous. If suitable checkdams are installed in the drainage channels, excess water can be removed or retained in the soil at the levels desired by removing or replacing the retards.

(2) RIVER FLOODS:

The Red River has overflowed its banks in Manitoba during the spring freshet at least twelve times since the disastrous year of 1826, when the flood stage at Winnipeg reached approximately 37 feet above datum*, and the pioneer Red River Settlement was completely demolished by the ravaging waters. A comprehensive report on historic Red River floods has been compiled by R.H. Clark as a Manitoba Department of Mines and Natural Resources' bulletin entitled, "Notes on Red River Floods". This report records that with the exception of eight years, continuous records of the peak flood stage at Winnipeg have been kept by the City Engineer's Office from 1875 to date. During this period the highest flood stage recorded prior to 1950 was 26.3 feet (City Datum), on May 6, 1882. Prior to 1875 there are records of the more serious floods only. The floods of 1826, 1852 and 1861 were chronicled by competent historians and a summary of their recordings is included in Clark's bulletin referred to above.

In 1826, the river rose to about elevation 37 feet (City Datum), the site of Winnipeg and St. Boniface was completely covered with water, and the whole valley appeared rather like a lake. All the inhabitants of the young settlement were forced to evacuate their homes and flee to the high land at Pine Ridge and Stony Mountain. The flood of 1852 was slightly less extensive but far more destructive due to the substantial growth of the settlement during the interim. In 1861, the high flood stage reached a level four feet below that of 1826 and was the last major inundation until 1950, when the water rose to within two feet of the 1861 level. Information on the earlier floods is not available for the reach of the river between Winnipeg and Emerson, but the extent of land inundated during the 1950 flood is shown in Figure No. 67. At the peak stage of this flood, approximately 640 square miles or 409,600 acres in Manitoba were under water and many of the towns along the river were evacuated.

The total area of the Red River basin is 111,000 square miles. The drainage area of the Red River, excluding the Assiniboine basin, is comprised of 40,200 square

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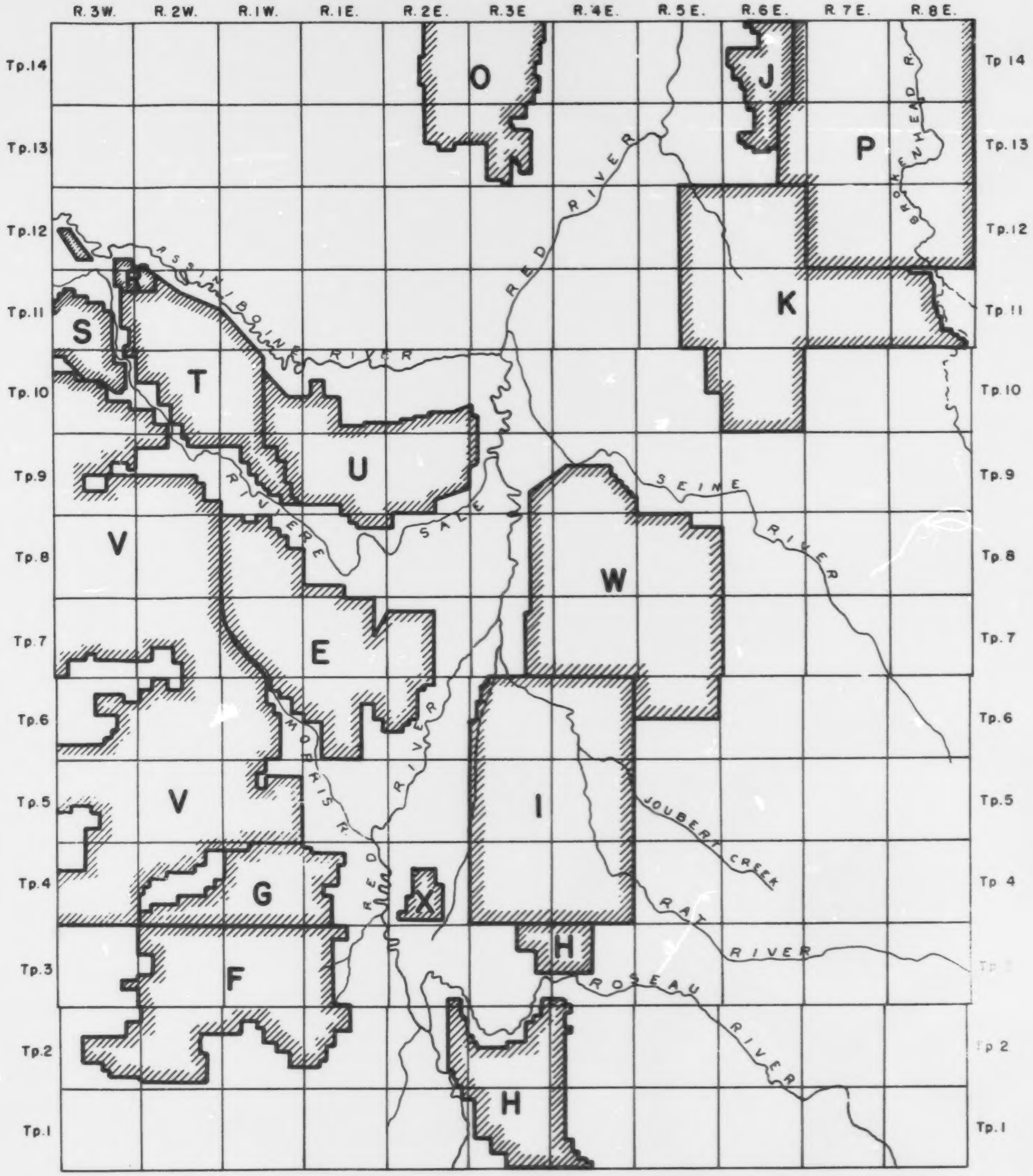
* Zero City Datum is 727.57 feet (A.S.L.) and flood stage measurements are recorded by means of a guage located at the foot of James Avenue. The flooding stage of the Red River at Winnipeg is considered to be approximately 18 feet above datum.

LOCATION OF ORGANIZED DRAINAGE DISTRICTS, IN THE WINNIPEG-MORRIS AREA.
(Under The Jurisdiction Of The Manitoba Drainage Maintenance Board)


R. 3W.
R. 2W.
R. 1W.
R. 1E.
R. 2E.
R. 3E
R. 4E.
R. 5E.
R. 6E.
R. 7E.
R. 8E.
Tp. 14
Tp. 13
Tp. 12
Tp. 11
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Tp. 9
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Tp. 7
Tp. 6
Tp. 5
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O
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K
S
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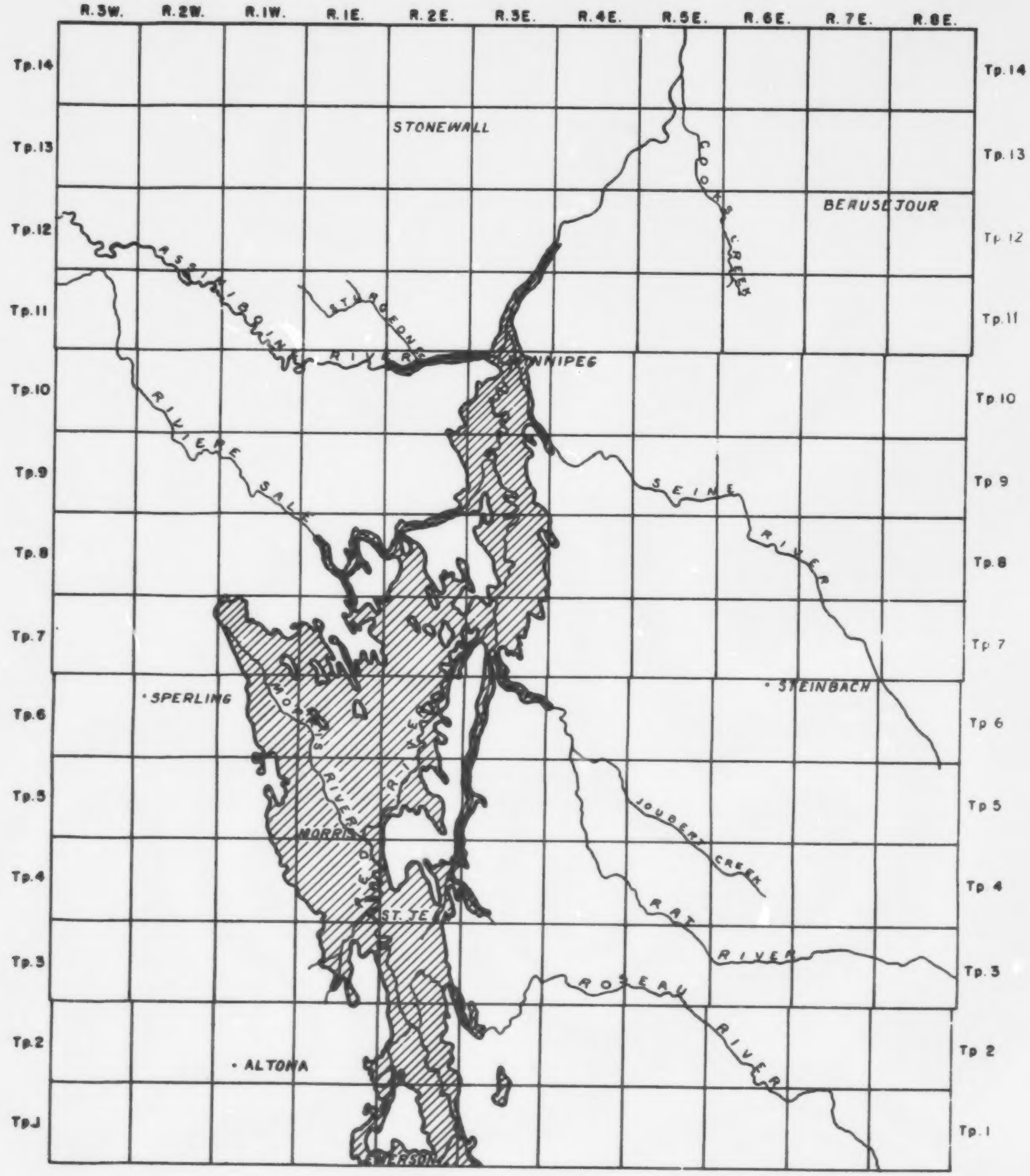
U
V
W
E
V
I
G
X
H
F
H
RED RIVER
ASSINIBOINE RIVER
BROKENHEAD R.
SEINE RIVER
RIVIERE SALE
MORRIS R.
RED RIVER
JOUBERT CREEK
RAT RIVER
ROSEAU RIVER

Figure No. 66

AREA IN THE CENTRAL LOWLAND INUNDATED BY WATER, IN MAY, 1950.

As recorded by R.H. Clark in "Notes on Red River Floods,"
Published by Provincial Department of Mines & Natural Resources, 1950.



R.3W.
R.2W.
R.1W.
R.1E.
R.2E.
R.3E.
R.4E.
R.5E.
R.6E.
R.7E.
R.8E.
Tp.14
Tp.13
Tp.12
Tp.11
Tp.10
Tp.9
Tp.8
Tp.7
Tp.6
Tp.5
Tp.4
Tp.3
Tp.2
Tp.1
STONEWALL
COOKS CREEK
BEAUSEJOUR
ASSINIBOINE RIVER
STURGEON CR.
WINNIPEG
RIVIERE SALE
SEINE RIVER
SPERLING
STEINBACH
MORRIS RIVER
RED RIVER
MORRIS
JOUBERT CREEK
RAT RIVER
ST. JEAN
ROSEAU RIVER
ALTONA
EMERSON

Figure No. 67

miles tributary to the Red River in the United States, and 8,300 square miles in Canada. The remaining 62,500 square miles is tributary to the Assiniboine River. The Red River flows along the lowest portion and slightly east of the central line of the Lake Agassiz basin. Many tributary rivers join the Red River south and north of the International Boundary. These tributaries have a fairly rapid descent into the valley, where their slopes are reduced to little more than that of the Red River. The flatness of the valley plain does not permit erosive velocities so that the Red River and its tributaries have not been able to cut adequate channels through the old lake bottom to carry flows at the high stages.

During the normal spring freshets, the waters of the Red River are contained within the river channel and no flooding occurs. However flooding is almost an annual occurrence on the lands adjacent to those sections of the Assiniboine River where the banks are exceptionally low. The cause of the exceedingly large flows which have been experienced in the Red River during the 1826, 1852, 1861 and 1950 floods have been established as a combination of: (i) a wet autumn: (ii) very severe and continued frosts before the snow falls, sealing up the marshes, lakes and saturated ground; (iii) heavy snowfall during the later part of the winter; (iv) a late and sudden spring; and (v) above normal rainfall over the entire drainage basin during the spring break-up.

Any one of these conditions would not produce a spring freshet out of the ordinary, but a combination of all of the causes provides large volumes of water such as those experienced in the flood years of the past, and in the future floods as great as those of the past can be expected to occur whenever there is a synchronization of the five conditions noted above.

It should be noted in conclusion that in addition to printed records of river floods, there is evidence recorded in soils and native vegetation which should not be overlooked or ignored. The Riverdale soils, which are shown on the soil maps as occurring on the lower flood plains and on the terraces within the Red and Assiniboine River channels, are recent alluvial deposits on which soil profile development is feeble or absent. The absence or feeble development of soil horizons together with the alternating layers of silt and leaf mat, indicate that periodic inundation during spring break-up is normal and frequent, and may be expected to occur in any year.

Moreover, the native vegetation growing on the river terraces and lower flood plains is specific. Elm, cottonwood, basswood and box-elder, along with an occasional ash and an undergrowth of shrub willows and dogwood, or a herbaceous cover of ferns, etc., are found naturally in the Red River Plain only on sites subject to periodic and frequent inundation. Thus this type of tree cover growing on recently deposited river silt and buried leaf litter is sufficient evidence of sites which, although they are highly suitable for plant growth and for use as parks, are unsuitable as building sites because of flood hazard. (See Figures No. 68 and 69.)

On the other hand the St. Norbert clay soils under oak woods, which fringe the streams above the river terraces and flood plains, occupy higher and drier sites. Oak woods growing on well-developed degrading soil profiles that do not show deposits of silt or recent alluvium are an indication that flooding from river overflow is not a normal condition.

The Oakville soils, shown on the soil map of the Winnipeg area, occupy what may be considered as the upper flood plain somewhat intermediate in position between the lake plain and the lower flood plain and river terraces. The soil parent material here also is river silt and clay derived from stream overwash or river flooding, but unlike the Riverdale soils, the Oakville soils show definite soil horizon development. The vegetation here consists of tree species common to the river terraces and lower flood plains as well as the bur oak which is dominant on the better-drained St. Norbert clay soils. This mixed tree growth occurs on sites where flooding by river overflow is only of occasional occurence and the proof of this is the soil horizons which can be observed in the soil profiles that are developing on these flood-plain deposits. Thus examination and knowledge of the soil and native vegetation should be an initial step in planning any building or land-use program in the vicinity of the rivers and streams of the Central Lowland area.

Figure No. 68
River terrace in Red River channel, showing elm, cottonwood, basswood, and box-elder, characteristic of the river terraces and lower flood plains that fringe the streams, in marked contrast to the prairie and aspen-oak vegetation of the lowland plain.

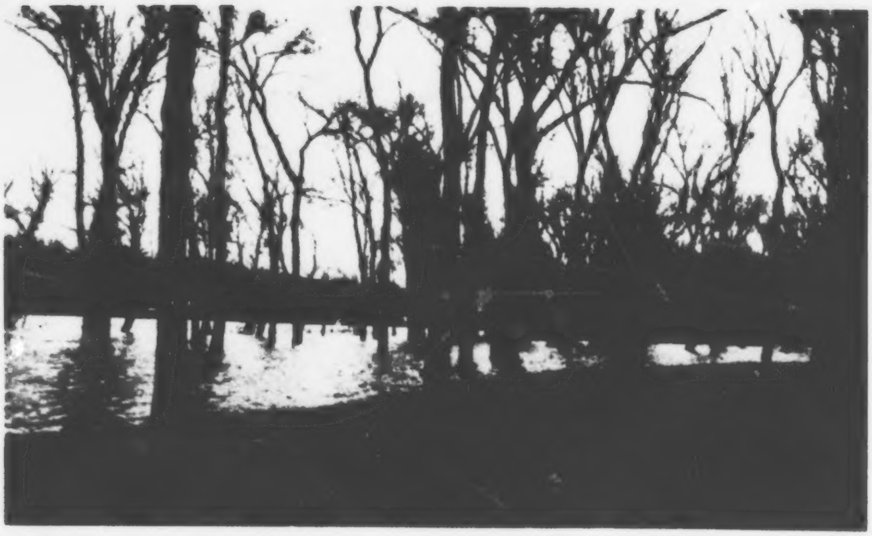


Figure No. 69
Red River terrace inundated by run-off water during break-up in the early spring. Such sites are excellent for use as parks, recreation areas, and market gardens, but are obviously unsuited for building sites due to the flooding hazard.

APPENDIX

I. General Explanatory Notes (and Field Classification of Soils).

II. Altitudes of Lake Agassiz Beaches in Manitoba.

III. Shipping Points, Grain Elevators, Stock Shipping Facilities, Creameries and Cheese Factories.

IV. Location of Administrative and Record Offices.

V. Experimental and Illustration Stations, and Sources of Agricultural Information.

APPENDIX I

GENERAL EXPLANATORY NOTES

(And Field Classification Of The Soils)

In Section 4 of this report, a brief outline was given of the procedure followed in conducting the reconnaissance soil survey of the Winnipeg-Morris area. In the same section it also was noted, that a "key", for the easy identification of the soils mapped, appears in this appendix. First however, the following explanatory notes are presented to develop a common understanding of soils and of the field system of soil classification that has been developed and used by the Manitoba Soil Survey.

(a) The Soil Profile: A cross section through the zone affected by the soil-forming processes exposes what is known as the "soil profile". In agricultural practice it is often customary to refer to different depth levels in the soil as "surface soil", "subsurface soil", and "subsoil", but because the respective soil horizons which make up the soil profile have definite significance and differ in depth with different soils, it is more fitting to use the specific pedological, or soil science, terms "A" horizon, "B" horizon, and "C" horizon.

The upper or "A" horizon is the horizon of maximum weathering, and of the maximum removal of the products of weathering by downward movement of the water which enters the soil from above. In a grassland soil the "A" or surface horizon also contains the maximum accumulation of organic deposition. The "B" or subsurface horizon (where it exists) lies below the "A" horizon; it is usually heavier and more compact as a result of the downward movement of clay and fine (colloidal) materials from the "A" horizon. Underlying the "B" horizon is the "C_1" horizon which may be only slightly altered by the soil-forming processes. This grades into the unaltered geological deposits that lie below the soil profile. The geological deposits on which the soil is developed are known as soil parent material. If organic matter occurs on the surface of the soil in the form of leaf mat or forest litter it is designated as the "A_0" layer. When soils have an accumulation horizon of lime carbonate (which may be present below the "A" or (where it exists) below the "B" horizon), such an accumulation horizon is designated by the symbol "Ca". In well-drained soils the lime carbonate accumulation indicates the average depth to which the soil is normally moistened by downward penetration of precipitation and where a periodic dry layer commonly occurs. In poorly drained soils the lime carbonate accumulation may mark the height to which the ground water periodically rises from below. Poorly drained soils, in which ground water stands in the soil profile, have a condition designated as "Gley" (i.e.; a layer in which reduction and anaerobic processes are active) that can be recognized by bluish grey, olive grey or mottled colors, and the presence of iron concretions or bog iron.

The various soil horizons that make up the soil profile may differ in depth, in color, in texture or size of particles, in structure or arrangement of particles into aggregates, in consistency and porosity etc., in mechanical intrusions and chemical concretions, and in reaction or alkalinity and acidity. The expression of these characteristics in the respective soil horizons reflects the soil-forming processes.*

(b) Factors Affecting Soil Type: The factors that control the soil-forming processes and determine the soil type are (1) the climate, or the temperature and moisture within the soil; (2) the vegetation, which in part affects the soil climate during growth and is the primary source of the organic matter; (3) the parent material, or the geological deposits which contribute the soil minerals and in turn affect the texture, the water retention capacity and the mineral reserve; (4) the position in which the soil is found in relation to topography; (5) the internal drainage, or the presence or absence of ground water within the soil; (6) the age, or the length of time during which the soil has been under the influence of the soil-forming processes; and (7) in the case of cultivated soils, the modifying effects of culture or the work of man.

The most important factor in soil formation is the soil climate, or the temperature and moisture within the soil. In virgin soils the climate determines the native vegetation which is produced, and the native vegetation in turn determines the type of organic matter that is deposited within or on the soil. Soil climate also determines the activity of micro-organisms, the rate of the production and decomposition of organic matter, the rate and extent of mineral weathering, and the extent to which the products of weathering are accumulated in or are removed from the soil.

Because of differences in topographical position and drainage, the soil climate may vary very considerably within relatively short distances in the same field. For example, the soils occurring on knolls or strongly sloping positions are "locally arid" (or drier and warmer than the normal soils) due to the fact that a large portion of the precipitation may run off. Soils in the depressions which receive the run-off waters in addition to the precipitation are "locally humid" (or wetter and cooler than the regional well-drained soils). The topographical position occupied by the soil, and the external and internal drainage within the soil, thus affect the soil climate, hence the soil climate should not be confused with the atmospheric climate. Soil climate is the chief factor affecting soil formation, and in the final analysis each individual soil is the result of the interaction of soil climate, vegetation (or organic life) and parent material (or mineralogical deposits).

All soils in the normal well-drained position in a given region will have a regional soil climate (except insofar as it may be modified by the kind and texture of the parent material and the vegetative cover); all normal or regional soils with the same regional climate will be subject to the same soil-forming processes and will tend to have similar major characteristics, providing, of course, that they are of a similar age or degree of development. On the other hand, variation in soil climate results in soil variation. The differences in soil climate brought about by difference in topographical position, drainage, etc., result in the development of local soils that differ from the regional soils with which they are associated.

It must be observed, therefore, that as the soil climate is modified by topographical position, a number of different soils may be found in association with each other on a given parent material or geological surface deposit. For example, on boulder till in the Blackearth soil zone, the prevailing normal or well-drained soil will be of the blackearth type, but the soil on the knolls will be a shallow phase Blackearth. In the depressions, either black Meadow soils or leached grey Meadow soils (Meadow Podzols) may be found surrounded by a fringe of Saline and Alkalinized soils, or by degrading Blackearths. Each of these soil types will show different profile characteristics when examined in cross section.

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* The main soil horizons may be subdivided for more detailed and accurate descriptions, in which case they may be designated as A_1, A_2, A_3; B_1, B_2, B_3; C_1, etc.

Soil-forming processes similar to those responsible for the development of these respective soil types will be in operation on the other geological surface deposits found in the same region, but the comparable soil types (groups) may show certain differences which are due to the texture and mineralogical composition of the parent material on which they are developed, as well as differences in degree of expression. For example, an examination of a Blackearth soil developed on calcareous boulder till, compared with a Blackearth soil developed on light textured lacustrine sediments, reveals varietal differences which are due to the material on which each is formed. The varietal differences exhibited in the respective comparable soil types are the result either of physical differences due to texture, or of chemical differences due to the mineralogical composition, lime reserve, etc.

(c) Soil Mapping: The foregoing explanatory notes emphasize the fact that soils (as they occur in the field) must be considered as a complex intermixture of types and variations which present serious difficulties in the preparation of a soil map. Soil maps may be either of the detailed or of the reconnaissance type. The difference between these two types of maps is in the scale and degree of detail shown. The ideal soil map would be a detailed map on a large scale which shows the occurrence and distribution of every soil found on every farm. On such a soil map, each soil type would be shown as a separate unit, but even on a detailed map it is impractical to show all the minor variations that can be observed in the field.

In a reconnaissance soil survey, the area involved and the scale of the map used is such that it is impossible to show each individual soil as a unit. In the reconnaissance soil maps of the Winnipeg-Morris area, each unit shown, in most cases, may be considered as a complex of types known as a soil association, having a dominant soil type interspersed with local soil types of minor importance. However, while the soil associations are generally shown as units on the reconnaissance soil map, local associated soils and textural classes are occasionally mapped or designated as separate units where the areas involved are sufficiently large or where such units are of sufficient local importance.

(d) Field Classification: In the Manitoba soil survey the associated genetic soil types that are developed on similar materials (or geological deposits) in the same zone are designated as a "soil association" and the individual associated soils (which are recognized by their soil profile characteristics) are referred to as "soil associates".* The soil associates may be subdivided into phases and textural classes if such a subdivision is required. The individual soil types or associates occurring in a given area are thus grouped into soil associations, and the common regional soil characteristics, that are expressed in the typical or well-drained soils of all the various associations (as the result of a common regional climate), provide the criteria for designating the soil zone to which they belong.

Thus, the various soil associations are made up of soil associates with different profile characteristics. These associates can be classed as genetic soil types that have developed under different drainage or moisture conditions, (namely; variation in local soil climate). A key to the field classification of the soil associations established in the Winnipeg area, and a similar key to the field classification of the soil associations in the Morris area are submitted as Table No. 20 and Table No. 21 respectively. These tables contain certain designating terms and symbols which may require the explanatory notes that are first presented in tabular form as Table No. 19. The characteristics by which the representative genetic soil types, referred to in Table No. 19, may be recognized are illustrated in Figure No. 70.

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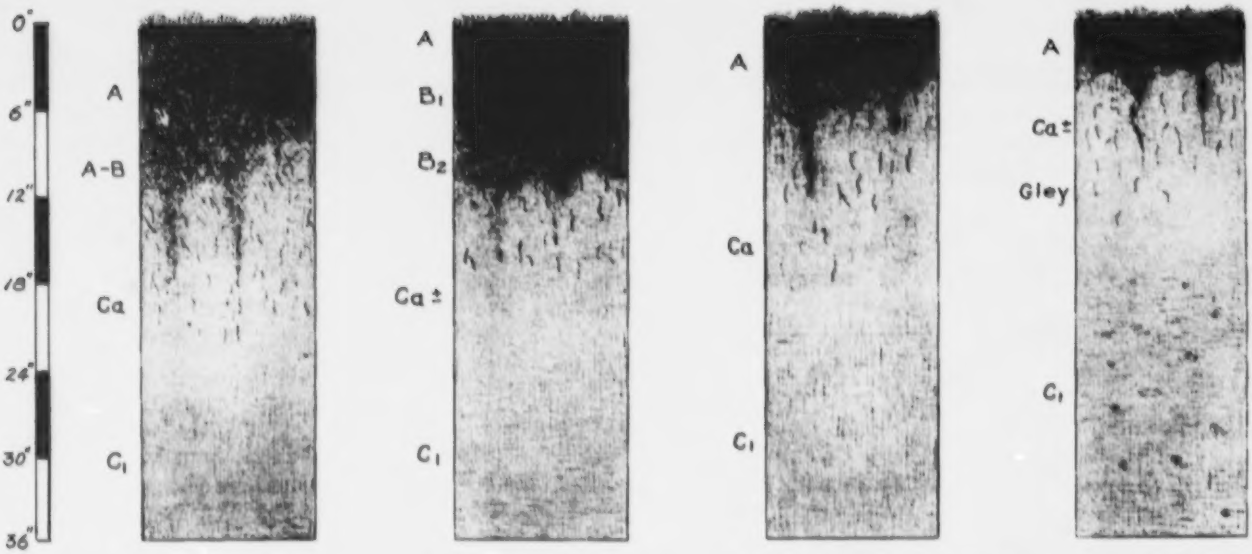
* In the U. S. Bureau of Soils' system a "soil associate" is designated as a "soil series".

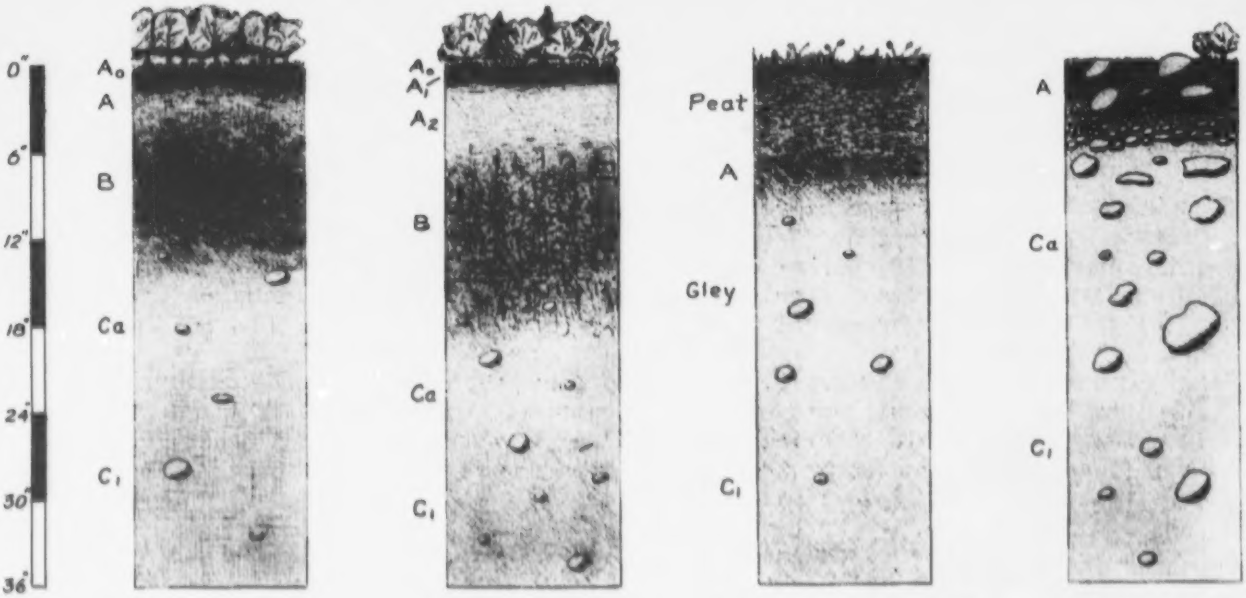

0"
6"
12"
18"
24"
30"
36"
A
A-B
Ca
C_1
A
B_1
B_2
Ca ±
C_1
A
Ca
C_1
A
Ca ±
Gley
C_1

BLACKEARTH SOIL

ALKALINIZED or SOLONETZIC SOIL

BLACKEARTH-MEADOW (INTERGRADE)

MEADOW SOIL


0"
6"
12"
18"
24"
30"
36"
A_0
A
B
Ca
C_1
A_0
A_1
A_2
B
Ca
C_1
Peat
A
Gley
C_1
A
Ca
C_1

GREY-BLACK SOIL

GREY-WOODED SOIL

PEATY-MEADOW SOIL

RENDZINA SOIL

Figure No. 70:- Representative Soil Profiles of Some Important Genetic Soil Types (or Groups) in the Winnipeg-Morris Area.

MAJOR CHARACTERISTICS BY WHICH THE GENETIC SOIL TYPES ILLUSTRATED IN FIGURE NO. 70 MAY BE RECOGNIZED.

Blackearth Soil. (Tall prairie-grass vegetation.) A, horizon of organic accumulation; A-B, thin transitional horizon; Ca, horizon of calcium carbonate accumulation; C_1, horizon of slightly altered geological material.

Alkalinized or Solonetzic Soil. (Tall prairie-grass vegetation.) A, dull horizon relatively low in organic matter; B_1, horizon of accumulation showing characteristic prismatic or columnar structure; B_2, horizon of accumulation and consisting of dark, shiny coated aggregates; Ca, horizon of calcium carbonate accumulation, may or may not be present; C_1, horizon of slightly altered geological material, may contain gypsum crystals and lime concretions.

Blackearth - Meadow (Intergrade). (Tall prairie-grass and meadow - prairie grass and herb vegetation.) A, horizon of organic accumulation; Ca, horizon of calcium carbonate accumulation; C_1, horizon of slightly altered geological material.

Meadow Soil. (Swale grass and sedge vegetation.) A, horizon of organic matter accumulation, more or less mucky; Ca, horizon of calcium carbonate accumulation, may or may not be strongly expressed; Gley, grey or mottled horizon under influence of ground water, containing iron concretions; C_1, horizon of slightly altered geological material.

Grey - Black Soil. (Deciduous forest invasion of tall prairie-grass vegetation.) A_0, leaf and sod mat; A, horizon of organic accumulation but more or less mottled grey and black showing slight evidence of leaching or degradation; B, horizon of dark coated aggregates showing nutty structure; Ca, horizon containing calcium carbonate concretions; C_1, horizon of slightly altered geological material.

Grey Wooded Soil. (Mixed deciduous and coniferous forest vegetation.) A_0, leaf mat; A_1, thin dark colored horizon of organic matter accumulation; A_2, grey, leached horizons; B, darker colored accumulation horizon showing nutty structure;Ca, horizon of calcium carbonate accumulation; C_1, horizon of slightly altered geological material.

Peaty Meadow Soil. (Swale grass, sedge, and moss vegetation.) Peat, organic deposit of fen, moss, woody or mixed peats; A, mucky horizon of mixed mineral and organic materials; Gley, blue grey to grey horizon under influence of ground water, containing iron concretions; C_1, horizon of slightly altered geological material.

Rendzina Soil. (Tall prairie-grass vegetation interspersed with aspen and willows.) A, horizon of organic accumulation; Ca, horizon of marly accumulation of calcium carbonate; C_1, horizon of slightly altered, highly calcareous, geological material.

TABLE NO. 19:- EXPLANATORY NOTATIONS OF SYMBOLS USED IN THE "KEY TO THE CLASSIFICATION OF THE SOILS" PRESENTED AS TABLE NO. 20 AND TABLE NO. 21.

Genetic soil types (or groups) that occur in association on similar soil parent materials; and the symbols used to designate the presence of the various zonal and intrazonal soils that together compose the specific soil associations, and to express the drainage conditions under which the respective genetic soils are commonly found in:-A_1 the Blackearth; A_2 the Grey - Black; and A_3 the Grey Wooded soil zones of the Winnipeg-Morris area.

Genetic Soil Types		Designating Terms	Designating Symbols
A_1 **BLACKEARTH SOIL ZONE:**			
C_1 Dominant soil normally well-drained, but in this area, due to local flat topography, drainage of dominant soil varies with the respective soil associations:-			
Blackearth	Occurring as well-drained	phytomorphic	associate = P
Blackearth-like	" " " well to intermediately drained	phyto-phytohydromorphic	associate = P-PH
Blackearth - Meadow (intergrade)	" " " intermediately drained	phyto-hydromorphic	associate = PH
C_2 Drainage in excess of the drainage common to the dominant soil:-			
(Eroded, truncated and excessively drained members (oro-phytomorphic) absent.)			
Blackearth	Occurring as well-drained	phytomorphic	associate = P
Blackearth-like	" " " well to intermediately drained	phyto-phytohydromorphic	associate = P-PH
Grey - Black soil	" " " well-drained	phytomorphic wooded	associate = Pw
Degrading Blackearth	" " " well to intermediately drained	phyto-phytohydromorphic wooded	associate = P-PHw
C_3 Intermediately drained soils:-			
Blackearth - Meadow (intergrade)	" " " intermediately drained	phyto-hydromorphic	associate = PH
Calcic Blackearth - Meadow (intergrade)	" " " intermediately drained	phyto-hydromorphic calcareous	associate = PH$_{Ca}$
Degrading Blackearth - Meadow (intergrade)	" " " intermediately drained	phyto-hydromorphic degrading	associate = PHw
C_4 Poorly drained soils:-			
Calcic Meadow soil (Gleysolic)	" " " poorly drained	hydromorphic calcareous	associate = HC$_a$
Meadow soil (Gleysolic)	" " " poorly drained	hydromorphic	associate = H
Meadow Podzol (Gleysolic)	" " " poorly drained	hydromorphic degraded	associate = Hd
Peaty Meadow soil (Gleysolic)	" " " very poorly drained	hydromorphic highly organic	associate = Ho
C_5 Periodically hydromorphic (alkali soils):-			
Salinized soil (Solonchak)	" " " salinized	halomorphic	associate = Gs
Alkalinised soil (Solonets)	" " " alkalinized	halomorphic	associate = G
Degraded alkali soil (Solod)	" " " degraded	halomorphic	associate = Gd
A_2 **GREY - BLACK TRANSITIONAL ZONE:**			
C_1 Dominant soils normally well-drained, but in certain soil associations may be intermediately drained:-			
Degrading Blackearth and weakly developed Grey Wooded soil)	Occurring as well-drained	phytomorphic	associate = Pw
Degrading Blackearth	" " " well to intermediately drained	phyto-phytohydromorphic	associate = P-PHw
Degrading Blackearth - Meadow (intergrade)	" " " intermediately drained	phyto-hydromorphic	associate = PHw

Table No. 19 (cont.)

Genetic Soil Types		Designating Terms		Designating Symbols
C_2 Drainage in excess of the drainage common to the dominant soil:-				
Blackearth	Occurring as	well-drained	phytomorphic	associate = P
Blackearth-like	" " "	well to intermediately drained	phyto-phytohydromorphic	associate = P-PH
Degrading Blackearth	" " "	well drained	phytomorphic wooded	associate = Pw
Degrading Blackearth	" " "	intermediately drained	phyto-phytohydromorphic wooded	associate = P-PHw
C_3 Intermediately drained soils:				
Blackearth - Meadow soil intergrades	" " "	intermediately drained	phyto-hydromorphic	associate = PH
Degrading Blackearth - Meadow soil	" " "	intermediately drained	phyto-hydromorphic wooded	associate = PHw
C_4 Poorly drained soils:-				
Calcic Meadow soil (Gleysolic)	" " "	poorly drained	hydromorphic calcareous	associate = HCa
Meadow soil (Gleysolic)	" " "	poorly drained	hydromorphic	associate = H
Peaty Meadow soil (Gleysolic)	" " "	poorly drained	hydromorphic highly organic	associate = Ho
Meadow Podzol (Gleysolic)	" " "	poorly drained	hydromorphic degraded	associate = Hd
A_3 GREY WOODED SOIL ZONE:				
C_1 Dominant soil normally well-drained:-				
Grey Wooded soil	" " "	well-drained	phytomorphic	associate = P
Humid Grey Wooded soil	" " "	intermediately drained	phyto-hydromorphic	associate = PH
C_2 Drainage in excess of the drainage common to the dominant soil:-				
Grey Wooded soil	Occurring as	well-drained	phytomorphic	associate = P
Grey - Black soil	" " "	well-drained	phytomorphic weakly degraded	associate = Pw
Moist Grey - Black soil	" " "	well to intermediately drained	phyto-phytohydromorphic wooded	associate = P-PHw
C_3 Intermediately drained soils:-				
Moist Grey Wooded soil	" " "	intermediately drained	phyto-hydromorphic	associate = PH
Humid Grey - Black soil	" " "	intermediately drained	phyto-hydromorphic weakly degraded	associate = PHw
C_4 Poorly drained soil:-				
Meadow Podzol (Gleysolic)	" " "	poorly drained	hydromorphic degraded	associate = Hd
Peaty Meadow soil (Gleysolic)	" " "	very poorly drained	hydromorphic highly organic	associate = Ho

TABLE NO. 20:- KEY TO FIELD CLASSIFICATION OF THE SOILS TO ACCOMPANY THE WINNIPEG AREA SOIL MAP

A_1 Areas in which the well-drained or regional soils are characterised by a relatively deep "A" (or surface) horizon, granular in structure, high in organic matter, and generally neutral to slightly alkaline in reaction; fading gradually into a relatively thin "A-B" or "B" subsurface horizon that is grey brown in color and slightly more compact than the "A" horizon, tending to form column-like clods or irregular aggregates when dry, and grading into a more or less carbonated horizon at depths which vary with the different materials on which the soils were formed..)---BLACKEARTH SOIL ZONE

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With the Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
Soils Developed on "Water-Deposited" Parent Material:							
(a) Fine Textured Sediments:							
B_1 Blackearth-like soils developed on lacustrine fine clays of the Lake Agassiz basin -- RED RIVER ASSOCIATION:							
(i) Blackearth-like soils with greyish brown clay subsoil — Well to Intermediately Drained Associate	Red River clay (P-PH)	Pw	PH_{Ca} PH	..	..	G	Gd
(ii) Shallow black Meadow soils with grey clay subsoil containing lime carbonate and limonite concretions, and sometimes gypsum crystals — Poorly Drained Associate	Osborne clay (H)	..	PH	Ho H_{Ca}	Gs	G-	..
(iii) Associated soils under tree invasion with a distinct grey "A_2" horizon and a tough "B" horizon — Wooded Associate	St. Norbert clay (Pw)	P	PH	..	..	..	..
B_2 Blackearth-like soils developed on fine lacustrine sediments with till or eroded till at depths ranging from 16 to 30 inches (±) -- MARQUETTE ASSOCIATION	Marquette clay to heavy clay loam (P-PH)	..	PH_{Ca} PH	Ho H_{Ca} H	Gs	G	..
B_3 Blackearth-like soils developed on a clay mantle over a light grey to pale yellow calcareous very fine sandy to silty clay subsoil which rests on lacustrine clay substratum -- FORT GARRY ASSOCIATION	Fort Garry clay (P-PH)	P-PHw	PH	H	Gs	G	Gd
(b) Medium Textured Sediments:							
B_4 Calcic blackearth-like soils with a moderately deep "A" horizon, that fades into a grey marly accumulation which grades into light grey to pale yellow subsoil -- EMERSON ASSOCIATION	Emerson silt loam to silty clay (P-PH)	P-PHw	PH	H_{Ca}	Gs	G	..
B_5 Weakly developed calcic blackearth-like soils with a shallow "A" horizon, very dark grey in color that fades into a strongly developed light grey marly accumulation, which grades into light grey to pale yellow subsoils -- LAKELAND ASSOCIATION	Lakeland fine sandy loams (P-PH)	..	PH	Ho H	Gs	..	..
	Lakeland clay loam to clay (PH)	P-PH	..	Ho H	Gs	..	..
(c) Coarse Textured Sediments:							
B_6 Coarse textured blackearth-like soils developed on gravel							

concretions, and sometimes gypsum crystals -- Poorly Drained Associate	Osborne clay (H)	..	PH	Ho H_{Ca}	Gs	G-	..
(iii) Associated soils under tree invasion with a distinct grey "A_2" horizon and a tough "B" horizon -- Wooded Associate	St. Norbert clay (Pw)	P	PH	..	..	..	..
B_2 Blackearth-like soils developed on fine lacustrine sediments with till or eroded till at depths ranging from 16 to 30 inches (±) -- MARQUETTE ASSOCIATION	Marquette clay to heavy clay loam (P-PH)	..	PH_{Ca} PH	Ho H_{Ca} H	Gs	G	..
B_3 Blackearth-like soils developed on a clay mantle over a light grey to pale yellow calcareous very fine sandy to silty clay subsoil which rests on lacustrine clay substratum -- FORT GARRY ASSOCIATION	Fort Garry clay (P-PH)	P-PHw	PH	H	Gs	G	Gd
(b) Medium Textured Sediments:							
B_4 Calcic blackearth-like soils with a moderately deep "A" horizon, that fades into a grey marly accumulation which grades into light grey to pale yellow subsoil -- EMERSON ASSOCIATION	Emerson silt loam to silty clay (P-PH)	P-PHw	PH	H_{Ca}	Gs	G	..
B_5 Weakly developed calcic blackearth-like soils with a shallow "A" horizon, very dark grey in color that fades into a strongly developed light grey marly accumulation, which grades into light grey to pale yellow subsoils -- LAKELAND ASSOCIATION	Lakeland fine sandy loams (P-PH)	..	PH	Ho H	Gs	..	..
	Lakeland clay loam to clay (PH)	P-PH	..	Ho H	Gs	..	..
(c) Coarse Textured Sediments:							
B_6 Coarse textured blackearth-like soils developed on gravel and coarse sandy beach deposits -- AGASSIZ ASSOCIATION	Agassiz loamy coarse sand to light sandy loam (P)	..	PH	..	..	..	..
Soils Developed on a Thin Mantle of Deltaic Deposits Over Eroded Till:							
B_7 Calcic blackearth-like and rendzina-like soils in the Blackearth zone developed on a thin mantle of very fine sandy or silty deltaic sediments underlain with eroded limestone boulder till -- WOODLANDS COMPLEX	Woodlands sandy loam to heavy clay loam (PH)	P-PH	..	H_{Ca}	Gs	..	..

A_2 Areas in which the well-drained or regional soils were originally of the Blackearth type but have been subsequently modified by woodland invasion. The "A" (or surface) horizon of the modified soils shows varying stages of transition from black to grey-black or grey (often a grey and black mottling), and is neutral to slightly acid in reaction. The "B" (or subsurface) horizon tends to be nutty in structure and the aggregates more or less coated with humus that has leached from the "A" horizon. The lime carbonate below the "B" horizon is concretionary and usually well defined, but it occurs at somewhat greater depth than in the corresponding adjacent Blackearths ....)----GREY - BLACK TRANSITIONAL ZONE

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With The Dominant Soil					
					C_5		
Soils Developed on Water-Deposited Parent Material:	C_1	C_2	C_3	C_4	D_1	D_2	D_3
(a) Fine Textured Sediments:							
B_1 Degrading Blackearth soils developed on fine lacustrine sediments with glacial till at depths ranging from 16 to 30 inches (±) -- PEGUIS ASSOCIATION	Peguis clay (P-PH)w	..	PH PHw	Hd Ho	..	..	..
(b) Medium Textured Sediments:							
B_2 Wooded blackearth-like soils developed on light grey water-laid deposits, under the influence of imperfect drainage, with a till or glacio-lacustrine substratum -- ZORA ASSOCIATION	Zora fine sandy loam (P-PH)w	P-PH ..	PH PHw	H_{Ca} Ho	..	..	..
	Zora loam to silty clay (PH)w	P-PH P-PHw	PH ..	H_{Ca} Ho	..	..	..

Soils Developed on a Thin Mantle of Fine Lacustrine Sediments Over Glacial Till:							
B_3 Degrading Blackearth soils developed on 6 to 15 inches (±) of clay loam to clay lacustrine sediments over calcareous till — SEMPLE ASSOCIATION	Semple clay loam to clay (P-PH)w	P Pw	PH PHw	H Hd Ho	..	..	..
Soils Developed on a Sandy Textured Outwash Mantle Over Till and Eroded Till:							
B_4 Degrading Blackearths developed on up to 15 inches (±) of sandy outwash mantle over reworked calcareous till — PELAN ASSOCIATION (Shallow Phase)....................	Pelan sandy loam to sandy clay loam (P-PH)w	P Pw	PH PHw	Hd H_{Ca} Ho H	..	..	..
B_5 Degrading Blackearth soils developed on 30 or more inches of sandy mantle over calcareous till — POPPLETON ASSOCIATION	Poppleton loamy sand to sandy loam (PH)w	P-PH P-PHw	PH ..	Hd Ho H	..	..	..

A_3 Areas in which the well-drained or regional soils have developed under forest vegetation and are characterized by a grey "A_2" horison that may be slightly acid in reaction and sometimes platy in structure, and a brown to greyish brown more or less nutty structured "B" horizon, grading into a lime carbonate accumulation horizon. (Black or grey mottled degrading Blackearths in varying stages of modification may be present as local soil associates.) .... }---GREY WOODED ZONE

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With The Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
Soils Developed on a Thin Mantle of Fine Lacustrine Sediments Over Calcareous Till:							
B_1 Grey Wooded soils developed on 6 to 15 inches (±) of clay loam to clay over calcareous till — SALTEL ASSOCIATION	Saltel clay loam to clay (PH)	..	PHw ..	Hd Ho	..	..	..
B_2 Grey Wooded soils developed on 16 to 30 inches (±) of heavy clay loam to clay over calcareous till — BROKENHEAD ASSOCIATION..................................	Brokenhead heavy clay loam to clay (P-PH)	P-PHw ..	PHw PH	Hd Ho	..	..	..
Soils Developed on a Sandy Textured Mantle Over Till and Eroded Till:							
B_3 Grey Wooded soils, developed on a sandy mantle less than 15 inches in depth over calcareous till; intermixed with degrading rendzina-like soils characterized by shallow profiles developed on calcareous till — GARSON COMPLEX..................................	Garson sandy loam to clay loam (P)	Pw ..	PHw PH	Hd Ho	..	..	..
B_4 Grey Wooded soils, developed on 30 or more inches of sandy mantle over calcareous till — PINE RIDGE ASSOCIATION	Pine Ridgeloamy sand to sandy loam (P)	Pw ..	PHw PH	Hd Ho	..	..	..
Soils Developed on Gravelly Outwash Sediments:							
B_5 Grey Wooded soils developed on gravelly and sandy deposits — BIRDS HILL ASSOCIATION	Birds Hill loamy sand to sandy loam (P)	Pw ..	PHw PH	Ho	..	..	..

A_4 Sub-Areas of local soils which occur in the Winnipeg map sheet area that have been determined primarily by either the character of the parent material or by immaturity. (Rendzina or highly calcareous soils with shallow profiles; juvenile soils on recent alluvium; and organic soils .... }---LOCAL SOIL AREAS

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With The Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
(a) RENDZINA SOILS -- Shallow highly calcareous soils with a thin "A" horison containing limestone or dolomite fragments:							
B_1 Soils developed on a more or less lake-washed limestone boulder till — ISAFOLD ASSOCIATION	Isafold loam to clay loam (P-PH)*	Pw	PH	Ho H	Gs	..	..
(b) ALLUVIAL SOILS — Juvenile soils developed on recent alluvial deposits:							
B_2 Fairly uniform light grey brown river terrace and flood-plain deposits with very feeble profile development -- (Immature soils of excellent arable value.) RIVERDALE ASSOCIATION	Riverdale silty clay						
B_3 Fairly uniform light grey brown river terrace and flood-plain deposits with juvenile profiles in varying stages of development toward maturity — OAKVILLE ASSOCIATION	Oakville silty clay loam to clay (P-PH)*	P-PHw	PH	H_{Ca} H Ho	Gs	G	..
(c) ORGANIC SOILS:							
B_4 Peat deposits over 10 inches in depth — BOG AND HALF-BOG							

* Soil associate symbols have a similar meaning to those which have been listed for the Blackearth zone in Table No. 19.

TABLE NO. 21:- KEY TO FIELD CLASSIFICATION OF THE SOILS TO ACCOMPANY THE MORRIS AREA SOIL MAP

A_1 Areas in which the well-drained or regional soils are characterized by a relatively deep "A" (or surface) horizon, granular in structure, high in organic matter, and generally neutral to slightly alkaline in reaction; fading gradually into a relatively thin "A-B" or "B" subsurface horizon that is grey brown in color and slightly more compact than the "A" horizon, tending to form column-like clods or irregular aggregates when dry, and grading into a more or less carbonated horizon at depths which vary with the different materials on which the soils were formed ....)— BLACKEARTH SOIL ZONE

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With The Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
Soils Developed on "Water-Deposited" Parent Material							
(a) Fine Textured Sediments:							
B_1 Blackearth-like soils developed on lacustrine fine clays of the Lake Agassiz basin — RED RIVER ASSOCIATION:							
(i) Blackearth-like soils with grey brown clay subsoil — Well to Intermediately Drained Associates....	Red River clay (P-PH)	Pw	PH_{Ca} PH	..	..	G	Gd
(ii) Shallow black Meadow soils with grey clay subsoil containing lime carbonate and limonite concretions, and sometimes gypsum crystals — Poorly Drained Associates.....................	Osborne clay (H)	..	PH	Ho H_{Ca}	Gs	G-	..
B_2 Relatively immature blackearth-like soils with light grey silty outwash subsoil — HORNDEAN COMPLEX	Horndean clay (PH_G)	..	PH	H	Gs	G	..
B_3 Blackearth-like soils developed on fine lacustrine sediments with till or eroded till at depths ranging from 16 to 30 inches (±) — MARQUETTE ASSOCIATION	Marquette clay to heavy clay loam (P-PH)	..	PH PH_{Ca}	Ho H_{Ca} H	Gs	G	..
B_4 Blackearth-like soils developed on an intermixture of Red River and Emerson soil parent materials — RED RIVER - EMERSON TRANSITION	(PH)	..	PH_{Ca}	H_{Ca} H	Gs	G	..
(b) Medium Textured Sediments:							
B_5 Calcic blackearth-like soils with a moderately deep "A" horizon, that fades into a grey marly accumulation which grades into light grey to pale yellow subsoil —	Emerson silt loam to silty clay loam (P-PH)	..	PH	H_{Ca}	Gs	G-	..
EMERSON ASSOCIATION	Emerson silty clay (PH)	P-PH P-PHw	..	H_{Ca}	Gs	G-	..
B_6 Deep Blackearth soils, irregularly tongued into light grey to light yellowish brown stream overwash and levee deposits, over a buried clay textured Meadow soil — SPERLING ASSOCIATION	Sperling mixed loams (P-PH)	..	PH_{Ca} PH	H_{Ca} H	..	..	..
B_7 Moderately deep Blackearth soils developed on a sandy outwash mantle superimposed over clay which in turn rests on boulder till — STEINBACH ASSOCIATION	Steinbach sandy loam to fine sandy clay loam (PH)	P-PHw P-PH	PHw	H_{Ca} H	Gs	..	..
B_8 Blackearth soils of sandy to medium texture with a very dark grey "A" horizon and a grey brown to light yellowish brown "B" horizon, and with a marly lime carbonate accumulation over light yellowish brown-colored substrate —	Altona Fine sandy loam (P)	..	PH_{Ca} PH	H_{Ca} H	Gs-	..	..
ALTONA ASSOCIATION	Altona very fine sandy clay loam (P-PH)	P	PH_{Ca} PH	H_{Ca} H	Gs	..	..
(c) Coarse Textured Sediments:							
B_9 Shallow coarse textured blackearth-like soils developed on gravel and coarse sandy beach deposits — AGASSIZ ASSOCIATION	Agassiz loamy coarse sand to light sandy loam (P)	..	PH	..	..	..	..
B_{10} Blackearth soils developed on up to 30 inches (±) of sandy mantle over calcareous till — KITTSON ASSOCIATION:							
(i) Sandy mantle up to 15 inches (±) in depth: Shallow Phase	Kittson sandy loam to sandy clay loam (P-PH)	Pw P	PH	Ho Hd H H_{Ca}	..	..	..
(ii) Sandy mantle 16 to 30 inches (±) in depth: Deep Phase	Kittson sandy loam (P-PH)	P Pw	PH PHw	H Hd Ho H_{Ca}	..	..	..
B_{11} Deep Blackearth soils developed on 30 inches or more of sandy outwash mantle over calcareous till — SPRINGBANK ASSOCIATION	Springbank sandy loam (P-PH)	Pw P	PH_{Ca} PHw PH	Ho Hd H H_{Ca}	..	..	..

A_2 Areas in which the well-drained or regional soils were originally of the Blackearth type but which have been subsequently modified by woodland invasion. The "A" (or surface) horizon of the modified soils shows varying stages of transition from black to grey (often a grey and black mottling), and is neutral to slightly acid in reaction. The "B" (or subsurface) horizon tends to be nutty in structure and the aggregates are more or less coated with humus that has leached from the "A" horizon. The lime carbonate below the "B" horizon is concretionary and usually well defined, but it occurs at somewhat greater depth than in the corresponding adjacent Blackearths ....)—GREY - BLACK TRANSITIONAL ZONE

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With The Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
Soils Developed on a Thin Mantle of Fine Textured Lacustrine Sediments Over Glacial Till:							
B_1 Degrading Blackearth soils developed on 6 to 15 inches (±) of clay loam to clay lacustrine sediments over calcareous till — SEMPLE ASSOCIATION	Semple clay loam to clay (P-PH)w	P Pw	PH PHw	H Hd Ho	..	..	..

Soils Developed on a Sandy Textured Mantle Over Till and Eroded Till:							
B_2 Degrading Blackearth soils developed on up to 30 inches (±) of sandy mantle over reworked calcareous till — PELAN ASSOCIATION:							
(i) Sandy mantle up to 15 inches (±) in depth: Shallow Phase	Pelan sandy loam to sandy clay loam (P-PH)w	P Pw	PH PHw	Hd H_{Ca} H Ho	..	..	..
(ii) Sandy mantle 16 to 30 inches (±) in depth: Deep Phase	Pelan sandy loam (PH)w	P-PH P-PHw	PH ..	Hd H_{Ca} H Ho	..	..	..
B_3 Degrading Blackearth soils developed on 30 or more inches of sandy mantle over calcareous till — POPPLETON ASSOCIATION	Poppleton loamy sand to sandy loam (PH)w	P-PH P-PHw	PH ..	Hd Ho H	..	..	..
B_4 Degrading Blackearth soils developed on 30 or more inches of stony, sandy outwash mantle containing one or more lenses of gravel, underlain with calcareous till — TOLSTOI ASSOCIATION	Tolstoi loamy sand to sandy loam (PH)w	P-PH P-PHw	PH	H Ho	..	..	..
Soils Developed on Gravelly Sediments:							
B_5 Shallow degrading Blackearth soils developed on gravelly and sandy beach and water-sorted deposits — LEARY ASSOCIATION	Leary loamy sand to sandy loam (P)w	P ..	PH PHw	..	..	..	..

A_3 Areas in which the well-drained or regional soils have developed under forest vegetation and are characterised by a grey "A_2" horizon that may be slightly acid in reaction and sometimes platy in structure; and a brown to greyish brown more or less nutty structured "B" horizon, grading into a lime carbonate accumulation horizon. (Blackearth or grey mottled degrading Blackearths in varying stages of modification may be present as local soil associates.) ....)---GREY WOODED ZONE

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring In Association With The Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
Soils Developed on a Thin Mantle of Fine Textured Lacustrine Sediments Over Calcareous Till:							
B_1 Grey Wooded soils developed on 6 to 15 inches (±) of clay loam to clay over calcareous till — SALTEL ASSOCIATION	Saltel clay loam to clay (PH)	..	PHw ..	Hd Ho	..	..	..
Soils Developed on a Sandy Textured Mantle Over Till and Eroded Till:							
B_2 Grey Wooded soils, developed on a sandy mantle less than 15 inches in depth over calcareous till; intermixed with degrading rendzina-like soils characterized by shallow profiles developed on calcareous till — GARSON COMPLEX	Garson sandy loam to clay loam (P)	Pw ..	PHw PH	Hd Ho	..	..	..
B_3 Grey Wooded soils developed on 16 to 30 inches (±) of sandy mantle over calcareous till — CALIENTO ASSOCIATION	Caliento sandy loam (PH)	Pw P	PHw ..	Hd Ho	..	..	..
B_4 Grey Wooded soils developed on 30 or more inches of sandy mantle over calcareous till — PINE RIDGE ASSOCIATION	Pine Ridge loamy sand to sandy loam (P)	Pw ..	PHw PH	Hd Ho	..	..	..
B_5 Grey Wooded soils developed on a stony, sandy mantle over 30 inches in depth containing one or more lenses of gravel, and underlain by calcareous till — VITA ASSOCIATION	Vita loamy sand to sandy loam (P-PH)	Pw ..	PHw PH	Ho	..	..	..
Soils Developed on Gravelly Outwash Sediments:							
B_6 Grey Wooded soils developed on gravelly and coarse sandy deposits — BIRDS HILL ASSOCIATION	Birds Hill loamy sand to sandy loam (P)	Pw ..	PHw PH	Ho	..	..	..

A_4 Sub-Areas of local soils which occur in the Morris map sheet area, that have been determined primarily either by the character of the parent material or by immaturity. (Sandy Podsols; juvenile soils on recent alluvium; and organic soils.)................)---LOCAL SOIL AREAS

Soil Association (or Soil Catena)	Soil Associates (or Series of Each Soil Catena)						
	Dominant or Representative Soil	Local Soil Types Occurring in Association With The Dominant Soil					
					C_5		
	C_1	C_2	C_3	C_4	D_1	D_2	D_3
(a) PODZOLS — Strongly leached soils without a textural profile developed on siliceous parent material:							
B_1 Deep sandy Podsols, under coniferous forest, with a light grey slightly acid "A_2" horizon which grades through a pale brown "B" horizon into siliceous slightly acid subsoil. A "Ca" horizon may or may not be found within the subsoil — MENISINO ASSOCIATION	Menisino loamy sand to sand (P)	..	PH	..	..	..	..
(b) ALLUVIAL SOILS — Juvenile soils developed on recent alluvial deposits:							
B_2 Fairly uniform light grey brown river terrace and flood-plain deposits with very feeble soil profile development (Immature soils of excellent arable value). RIVERDALE ASSOCIATION	Riverdale silty clay						
B_3 Undifferentiated recent variable alluvial deposits — ALLUVIUM							
(c) ORGANIC SOILS:							
B_4 Organic deposits 10 to 30 inches (±) in depth — HALF BOG							
B_5 Organic deposits more than 30 inches in depth — BOG							

APPENDIX II

Altitudes of Lake Agassiz Beaches in Manitoba*

Beaches		On The International Boundary	On The Latitude Of Gladstone, Arden and Neepawa
Herman Beaches	(a......	1230	.....
	(aa.....	1222	.....
	(b......	1212	1315
	(bb.....	1205	1295
	(c......	1190	1275
	(d......	1180	1255
	(dd.....	1175	1245
Norcross Beaches	(a......	1145	1215
	(b......	1130	1185
Tintah Beaches	(a......	1105	1150
	(b......	1080	1120
Campbell Beaches	(a......	1045	1080
	(aa.....	1035	1070
	(b......	1022	1055
McCauleyville Beaches .	(a......	1007	1035
	(aa.....	998	1023
	(b......	990	1012
Blanchard Beaches	(a......	975	995
	(b......	960	980
	(c......	947	965
Hillsboro Beach		935	953
Emerado Beach		902	920
Ojata Beach		877	895
Gladstone		857	875
Burnside Beach		837	855
Ossowa Beach		822	840
Stonewall Beach		805	820
Niverville Beach		...	775

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* Upham, Warren; "Glacial Lake Agassiz in Manitoba", Geological and Natural History of Canada, 1890, Page 92E.

APPENDIX III

Shipping Points, Grain Elevators and Stock Shipping Facilities in Winnipeg-Morris Area, Manitoba.

Station or Siding	Railway	Number of Elevators	* Bushel Capacity Of:-		Loading Platform Facilities +	Stockyard Facilities +
			Permanent Storage	Temporary Storage		
Woodlands	C,N.R.	...	....	....	x	x
Warren	C.N.R.	2	98,000	....	x	x
Grosse Isle	C.N.R.	1	30,000	....	x	x
Drake	C.N.R.	...	....	....	...	...
Argyle	C.N.R.	1	30,000	....	x	x
Gordon	C.N.R.	1	40,000	....	x	...
Moore	C.N.R.	...	....	....	x	...
Semple	C.N.R.	...	....	....	x	x
Vivian	C.N.R.	...	....	....	x	x
Anola	C.N.R.	...	....	....	x	x
Dugald	C.N.R.	1	35,000	....	x	...
Transcona	C.N.R.	1	1,600,000	200,000	...	...
Paddington	C.N.R.	...	....	....	...	...
Navin	C.N.R.	...	....	....	...	...
Lorette	C.N.R.	...	....	....	x	...
Dufresne	C.N.R.	1	40,000	....	x	...
Ste. Anne	C.N.R.	1	35,000	35,000	x	x
Giroux	C.N.R.	...	....	....	x	x
La Broquerie	C.N.R.	...	....	....	...	...
Marchand	C.N.R.	...	....	....	...	...
Emerson	C.N.R.	1	42,000	....	x	x
Stockport	C.N.R.	1	16,000	....	x	...
Fredensthal	C.N.R.	1	50,000	....	x	...
Ridgeville	C.N.R.	2	95,000	....	x	x
Tolstoi	C.N.R.	...	....	....	x	x
Stuartburn	C.N.R.	...	....	....	...	...
Vita	C.N.R.	...	....	....	x	x
Caliento	C.N.R.	...	....	....	x	x
St. Norbert	C.N.R.	...	....	....	x	...
Cartier	C.N.R.	...	....	....	x	...
Glenlea	C.N.R.	...	....	....	x	...
Ste. Agathe	C.N.R.	1	30,000	....	x	...
Union Point	C.N.R.	...	....	....	x	...
Silver Plains	C.N.R.	1	40,000	30,000	x	...
St. Jean Baptiste	C.N.R.	3	105,000	21,000	x	x
Letellier	C.N.R.	2	144,000	....	x	...
Christie	C.N.R.	1	30,000	....	x	...
Searle	C.N.R.	1	110,000	....	...	...
Oakbluff	C.N.R.	...	....	....	x	x
Sanford	C.N.R.	1	110,000	....	x	x
Brunkild	C.N.R.	3	105,000	85,000	x	x
Mollard	C.N.R.	1	30,000	180,000	...	...
Sperling	C.N.R.	3	120,000	100,000	x	x
Homewood	C.N.R.	3	105,000	65,000	x	x
Lowe Farm	C.N.R.	3	110,000	85,000	x	x
Kane	C.N.R.	2	115,000	30,000	...	...
Myrtle	C.N.R.	1	56,000	....	x	x
St. Charles	C.N.R.	...	....	....	...	...
Diamond	C.N.R.	...	....	....	...	...
Calrin	C.N.R.	...	....	....	x	...
White Plains	C.N.R.	...	....	....	x	...
Dacotah	C.N.R.	1	35,000	23,000	x	...
Elie	C.N.R.	2	70,000	60,000	x	x
Benard	C.N.R.	1	40,000	....	x	...
North Elie	C.N.R.	...	....	....	...	...
Cabot	C.N.R.	1	27,000	....	x	...
Beaudry	C.N.R.	...	....	....	x	...
East Selkirk	C.N.R.&C.P.R.	2	60,000	35,000	x	x
Gonor	C.N.R.&C.P.R.	...	....	....	x	...
St. Boniface	C.N.R.&C.P.R.	13	2,152,000	....	x	x
Winnipeg	C.N.R.&C.P.R.	13	2,230,000	40,000	x	x
Emerson	C.N.R.&C.P.R.	1	42,000	....	x	x
Morris	C.N.R.&C.P.R.	3	160,000	21,000	x	x
Reaburn	C.P.R.	...	....	....	x	x
Marquette	C.P.R.	2	70,000	....	x	x
Meadows	C.P.R.	2	90,000	....	x	x
Rosser	C.P.R.	1	34,000	30,000	x	x
Bergen	C.P.R.	...	....	....	x	...
Woodman	C.P.R.	...	....	....	...	...
Stonewall	C.P.R.	1	40,000	40,000	x	x
Stony Mountain	C.P.R.	...	....	....	x	x
Bears	C.P.R.	...	....	....	...	...
Clandeboye	C.P.R.	1	40,000	....	x	x

APPENDIX III (continued)

Shipping Points, Grain Elevators and Stock Shipping Facilities in Winnipeg-Morris Area, Manitoba.

Station or Siding	Railway	Number of Elevators	Bushel Capacity Of:- *		Loading Platform Facilities +	Stockyard Facilities +
			Permanent Storage	Temporary Storage		
Selkirk	C.P.R.	1	40,000	....	x	...
Lower Fort Garry ..	C.P.R.	1	40,000	10,000	x	...
Parkview	C.P.R.	...	....	....	x	x
Middle Church	C.P.R.	...	....	....	...	...
Donan	C.P.R.	...	....	....	...	...
Sinnot	C.P.R.	...	....	....	...	...
Beausejour	C.P.R.	2	105,000	....	x	...
Saldo	C.P.R.	...	....	....	...	...
Tyndall	C.P.R.	1	35,000	....	x	...
Garson	C.P.R.	...	....	....	x	...
Birds Hill	C.P.R.	...	....	....	x	...
Marconi	C.P.R.	...	....	....	...	...
Lydiatt	C.P.R.	...	....	....	x	...
Cloverleaf	C.P.R.	1	28,000	....	x	...
Hazelridge	C.P.R.	2	80,000	20,000	x	...
Oakbank	C.P.R.	1	35,000	....	x	...
Moose Nose	C.P.R.	...	....	....	...	....
Norcran	C.P.R.	...	....	....	...	...
North Transcona ...	C.P.R.	1	1,000,000	....	...	...
Grande Pointe	C.P.R.	...	....	....	x	x
Willard	C.P.R.	...	....	....	x	...
Niverville	C.P.R.	1	35,000	....	x	...
Otterburne	C.P.R.	1	30,000	....	x	x
Carey	C.P.R.	2	65,000	40,000	x	...
Dufrost	C.P.R.	3	155,000	40,000	x	...
Arnaud	C.P.R.	2	85,000	25,000	x	...
Dominion City	C.P.R.	2	86,800	55,000	x	x
Riordan	C.P.R.	...	....	....	x	...
St. James	C.P.R.	...	....	....	x	...
Fort Whyte	C.P.R.	...	....	....	...	...
Fortress	C.P.R.	...	....	....	x	...
La Salle	C.P.R.	1	40,000	26,000	x	x
Domain	C.P.R.	2	70,000	60,000	x	x
Osborne	C.P.R.	1	40,000	....	x	x
McTavish	C.P.R.	...	....	....	x	...
Sewell	C.P.R.	1	26,000	24,000	x	...
Rosenfeld	C.P.R.	3	128,000	84,000	x	x
Altona	C.P.R.	5	335,500	204,000	x	x
Gretna	C.P.R.	5	217,000	30,000	x	...
Horndean	C.P.R.	1	53,500	....	x	...
Plum Coulee	C.P.R.	4	183,000	141,000	x	x
Murray Park	C.P.R.	...	....	....	x	...
Headingly	C.P.R.	1	25,000	40,000	x	...
Springstein	C.P.R.	...	....	....	x	...
Starbuck	C.P.R.	3	125,000	90,000	x	...
Fannystelle	C.P.R.	3	267,000	....	x	x

* Information supplied through courtesy of Boards of Grain Commissioners, Winnipeg, Manitoba.

+ Information supplied through courtesy of J.D. Guild, Superintendent, Agricultural Development, Canadian National Railways, Western Region; and J.R. Almey, General Agricultural Agent, Canadian Pacific Railways, Prairie Pacific Regions. x indicates the respective facility is present.

Location of Creameries Within the Winnipeg-Morris Area (1951):++

Beausejour
Carman
Fort Garry
Gardenton
St. Boniface (2)
Steinbach
Tolstoi
Vita
Winnipeg (8)

Location of Cheese Factories Within the Winnipeg-Morris Area (1951):

Fort Garry
Giroux
Grunthal
Kleefeld
St. Boniface
Steinbach
Winnipeg (3)

++ As listed in Manitoba Crop Reporting Bulletin

APPENDIX IV

Location of Administrative And Record Offices In The Winnipeg-Morris Area, Manitoba.

(1) Municipal Offices:-

Municipalities	Municipal Office
Woodlands	Woodlands
Rockwood	Stonewall
St. Andrews	Clandeboye
St. Clements	East Selkirk
Brokenhead	Beausejour
St. Francois Xavier	St. Francois Xavier
Cartier	Elie
Rosser	Rosser
Assiniboia	Kirkfield Park
Charleswood	Charleswood
St. James	St. James
East St. Paul	Birds Hill
West St. Paul	Middle Church
Old Kildonan	211 Phoenix Building, Winnipeg
North Kildonan	6 Imperial Bank Building, Winnipeg
East Kildonan	755 Henderson Highway, Winnipeg
West Kildonan	West Kildonan
St. Vital	St. Vital
Fort Garry	Fort Garry
Springfield	Oakbank
Roland	Roland
Macdonald	Sanford
Morris	Morris
Ritchot	St. Adolphe
Tache	Lorette
Ste. Anne	Ste. Anne
Hanover	Steinbach
De Salaberry	St. Pierre
La Broquerie	La Broquerie
Rhineland	Altona
Montcalm	Letellier
Franklin	Dominion City
Stuartburn (L.G.D.)	Vita

(2) Land Titles Offices: -

Township	Range	Location of Land Titles Office
1-14	1E-8E	Winnipeg
6-14	1	Winnipeg
9-14	2	Winnipeg
13-14	3	Winnipeg
1-5	1-3	Morden
6-8	2-3	Carman
9	3	Carman
10-12	3	Portage La Prairie

APPENDIX V

EXPERIMENTAL AND ILLUSTRATION STATIONS.

Experimental and Illustration Stations that serve the Winnipeg-Morris area are listed below.

(a) Experimental Stations:-

Fort Garry -- University of Manitoba

University Experimental Station
Dominion Laboratory of [illegible] Pathology
Dominion Laboratory of Cereal Breeding
Dominion Forest Insect Laboratory
Provincial Veterinary Laboratory
Provincial Fur Research Station.

Morden -- Dominion Experimental Station
Section 4, Township 3, Range 5W

(b) Illustration Stations:-
(under supervision of Dominion Experimental Farm, Brandon, Manitoba)

Morris -- Dominion Illustration Station
N.W.$\frac{1}{4}$ and N$\frac{1}{2}$ of N.E.$\frac{1}{4}$ Section 33, Township 4, Range 2E

Beausejour -- Dominion Illustration Station
E$\frac{1}{2}$ of N.W. $\frac{1}{4}$, N$\frac{1}{2}$ of S.E. $\frac{1}{4}$ and L.S.D. 1,2,3, and 4 of
the N.E. $\frac{1}{4}$ Section 24, Township 13, Range 7 E

AGRICULTURAL EXTENSION SERVICE PROJECTS.

Particulars of the activities of District Agricultural Representatives, Agricultural Societies, Agricultural Education, Co-operative Marketing Organizations, etc., may be obtained from the Provincial Department of Agriculture, Winnipeg, Manitoba.

MAPS
NOT
FILMED

CARTES
OMISES